The Growth of Intelligence

A DISSERTATION
PRESENTED TO THE
FACULTY OF PRINCETON UNIVERSITY
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

BY
EDGAR A. DOLL

PRINCETON:
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ACKNOWLEDGMENTS

This study has been in progress since 1909. Undertaken originally by Dr. Henry H. Goddard, then Director of Research at The Training School at Vineland, N. J., it has since 1912 been carried forward under the immediate direction of the present author. The principal experimental data have been collected by a corps of conscientious colleagues and assistants under the general direction of Dr. Goddard. The analysis of these results was the principal research problem of the writer while a member of the Research Staff of The Training School. Final presentation was necessarily postponed until the present because of the unusually intricate and detailed nature of the material, necessitating numerous by-studies and long-continued re-examining. Preliminary reports on special aspects of the data have been previously published as "Notes" and as minor research studies.

I am indebted to Dr. Goddard for his original work on the material and for his keen interest and advice in formulating the problems and suggesting modes of treatment. I am also indebted to Mr. E. R. Johnstone, Superintendent of The Training School, for permission to use the material for publication. Dr. S. D. Porteus, the present Director of Research, has cordially assisted me by furnishing recent re-examinations designed to bring the material up to date, and by supplying me with certain otherwise inaccessible materials, information and references.

I am deeply indebted to Prof. Howard C. Warren for the present opportunity to present the results of the study. His appreciative interest and helpful suggestions overcame the final material and technical obstacles to publication. I am specifically grateful to him for assistance in formulating the objective rules for scoring incomplete examinations, thus overcoming a serious technical error in the material. Prof. H. C. McComas also gave valued suggestions regarding the organizing of the material and in suggesting modifications of presentation.

In particular I received constant material assistance from my wife in preparing the material. Her steady encouragement, also, in the tedium of so protracted an investigation and her intimate appreciation of the difficulties encountered have served to dissipate frequent misgivings as to the outcome.

EDGAR A. DOLL.

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I. THEORETICAL CONSIDERATIONS

Psychologists have tended to avoid a thorough analytical discussion of the growth of intelligence. One finds an obvious lack in psychological theory when one searches for hypotheses regarding individual differences in the growth of intelligence. The present study aims to formulate certain principles of intellectual growth on the basis of experimental inquiry into certain more or less generally accepted theories.

The nature of intelligence.—A serious obstacle is met at the outset when one attempts to define intelligence. The hey-day of faculty psychology is not yet sufficiently distant for us to have become completely freed from its influences. We do indeed assert that mind is a unity, but our text-books bear witness that we not only retain the faculty concepts but persistently employ them. Specific mental 'faculties' still flourish as 'mental functions,' or 'mental processes.' Even when such faculty concepts as association, memory, or discrimination are regarded as only different aspects of a unit mind they are commonly considered as parts of a mental mosaic rather than as different forms of a plastic whole.

In our own day even if one escapes the pitfalls of mental processes one still feels obliged to acknowledge the traditional distinctions of intelligence, feeling and will. The distinctions, to be sure, become daily less obvious, yet even the most ardent of the advocates of intelligence as the fundamental mental process persist in keeping the distinction.

Since Binet, however, there has been a marked tendency to yield the palm to intelligence as the most significant aspect of total mentality. The emotional and volitional aspects are not lost sight of, but are rather clearly differentiated from the intellectual aspects. The mental processes as units are by some made much of as the analytical component parts of the intelligence. By others they are ignored as an intangible complex which makes the whole but cannot distinctly be set off from it.

We purpose to avoid the philosophical and psychological questions involved in these different points of view. We shall assume such a fairly clear separation of emotion and will from intelligence as is commonly accepted by psychologists of our day. We shall also avoid the argument regarding intellectual mental processes and content ourself with a somewhat cursory review of the standpoints of the recognized authorities.

Spearman (19)[1] believes there are two factors in every intellectual reaction, (1) a general factor (the *general intelligence,* otherwise undefined except by physiological analogy) which pervades all intellectual reactions in greater or less degree, and (2) a specific factor (in terms of the elements of structural psychology) which characterizes the particular nature of a given intellectual reaction.

A clear view for practical purposes is that of Binet and Simon (2, 3). They view intellectual action as a complex function. They say (2, p. 42):

"It seems to us that in intelligence there is a fundamental faculty, the alteration or the lack of which is of the utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intelligence. A person may be a moron or an imbecile if he is lacking in judgment; but with good judgment he can never be either. Indeed the rest of the psychology of intelligence seems of little importance in comparison with judgment."

Specific mental processes such as perception or discrimination are for Binet and Simon 'phenomena of intelligence.'

In a later study Binet and Simon analyze the 'thought process' or the *modus operandi* of intelligence into three essential elements (3, pp. 130-155). In the course of a remarkable discussion on the nature of thinking they say (p. 136): "Thought, as we believe, is composed of three distinct elements; a *direction,* an *adaptation,* and a *criticism,*" and they follow this with an ex-

[1] Numbers in parenthesis refer to bibliography.

position which is as yet unrivalled in keenness of insight and clearness of presentation.

To these views we may add another distinctive feature of intelligence which is commonly accepted, namely the concept of intelligence as a *capacity,* which is relatively independent of specific abilities. This capacity is considered in relation to relatively new or unaccustomed situations. As a capacity it is considered to be innate rather than acquired, is modified more by heredity than by environment, is relatively unaffected by education except as education facilitates normal function of the capacity, is relatively independent of acquisitions except as these are symptoms of the capacity, and is subject to significant modifications only indirectly through forces which favor or hinder mental and physical growth through the physiological mechanisms of nutrition. This concept of intelligence is well formulated in the definition of Stern (28) who says (p. 3): "Intelligence is a general capacity of an individual consciously to adjust his thinking to new requirements: it is general mental adaptability to new problems and conditions of life." In this definition stress is laid on intelligence as a *capacity,* which is *general,* whose function is to facilitate *adaptation, consciously,* to *changed* conditions. Hence memory, habit, association, learning and such specific mental processes are excluded from intelligence. They are rather as Binet has said 'phenomena of intelligence,' parts of the whole but never the whole itself. Intelligence in some degree controls memory as a mental process, and memory as a process conditions to some degree the amount and kind of intelligence which an individual possesses, but the one is never the other. And so of the other phenomena of intelligence.

Intelligence and Intellect.—It is necessary, for some purposes, to differentiate intelligence from intellect. This is a difficult matter since in common usage the terms are interchangeable. Mark Baldwin's *Dictionary of Philosophy and Psychology* gives 'intelligence' as a synonym for 'intellect' and recognizes no clear distinction between the terms. He favors the use of either term to stand for *cognitive capacity.* There is, however, some inclination among modern psychologists to keep a distinction between these terms and a tendency is observed to restrict intelligence to the *capacity* for understanding (or conscious adaptations) and intellect to the *sum-total* of the understanding (or adaptation mechanisms). Or, intelligence is con-

sidered as "the intellect as an innate capacity or endowment" (*cf.* Webster).

We note a difficulty in the use of adjectives when one attempts to distinguish between intelligence and intellect. The adjectives 'intelligent' and 'intellectual' commonly mean 'possessed of intelligence' or 'characterized by evidence of intellect.' 'Intelligential' is the adjective for things pertaining to intelligence, but this term is not commonly used. We shall therefore adhere to the common usage and employ 'intellectual' as the adjectival form of intelligence to mean relation to intelligence. By 'intellectual growth' we shall hereafter mean specifically growth in intellect as a capacity.

To sum up then, we may recognize intelligence as an aspect of mental operation rather clearly set apart by common consent from emotion and will as concomitant aspects. We may consider intelligence in four ways: (1) as a general ability, otherwise undefined, which pervades and controls all mental action outside the field of emotion and will, or (2) as a compound of the specific mental processes of structural psychology, or (3) as a fundamental faculty whose essential activities are judgment, comprehension and reasoning and in relation to which the so-called simpler mental processes are phenomena, or (4) as a general capacity for conscious adaptation to new conditions of life.

It is perhaps well to remark that the term 'intelligence' has long been used in the field of animal psychology with a rather different meaning. In animal psychology, however, 'intelligence' seems at first to have been used in a rather figurative sense to contrast instinctive reactions with modifiable or learned reactions. The degree of modifiability of response seems to have been taken as a measure of any living organism's intelligence. But when one searches for definitions or criteria of intelligence in the field of animal psychology one finds little clearness of meaning. Some careful writers avoid the term with evident purpose. Thorndike (32) gives no direct definition of animal intelligence but appears to identify it with the *associative process* (p. 20). Thorndike rather indirectly indicates that his criterion of intelligence is ability to 'profit from experience.' Holmes (20) defines intelligence as 'the power to form associations' (p. 181). These are apparently analogous if not identical with Loeb's criterion of 'associative memory.'

There is reason for taking exception to the use of intelligence in these meanings on the grounds of etymology. From the point of view of etymology 'intelligence' must include the idea of understanding, comprehension or reasoning (*cf.* any dictionary). This cognitive element of intelligence is accepted as essential by Mark Baldwin.

The course of intellectual growth.—From this hasty review of the concepts of intelligence now current in psychology it appears

that the most acceptable definition of intelligence for purposes of this study is the formulation of Stern, namely, that intelligence is the general capacity for conscious adaptation to new situations. This formulation has met with practically universal approval among students of human intelligence (though it may not fit the needs of animal psychologists). Intelligence is, then, mental power to grasp and adequately deal with new problems. It may be measured (1) by means of a few types of problems, each type graded in difficulty (as in the Army Group Test Alpha and the scales devised by Squires and by Woolley), or (2) by means of a graded series of many different types of problems (as in the Binet Scales).

Both methods are employed in measuring intelligence, indeed they have given rise to two schools in applied mental measurement. Without going into the academic question of the relative merits of the two methods we may say that while the method of many problems graded plus or minus (passed or missed) in a scale of approximate difficulty has proved most successful in individual mental examinations, the method of a few problems which yield a quantitative measure of success in each has recently proved eminently successful for group mental examinations, notably in the Army.

By either method the practical result is much the same when allowance is made for statistical inaccuracies and inadequate standardization of test materials. To be successful such scales and tests must actually measure *general power* to apprehend rather than special accomplishment or specific aptitudes. Granting such a scale, adequately standardized and of sufficient range, what is the course of growth that we should expect to be registered by such a scale when applied year after year to individual subjects throughout their development periods? This is a problem of immediate and pressing importance for theoretical psychology as well as for the applications of psychology to the problems of human welfare.

Average normal mental growth.—The Binet Scale is standardized empirically in such a manner that unselected subjects of different ages will obtain mental age scores which on the aver-

age correspond to their average life ages. The statistical methods underlying such standardization in relation to the single tests in the Scale are as yet empirical. Their present sole justification lies in the empirical satisfactoriness of the Scale.

Otis (27) has made the most careful logical and mathematical analysis of the statistical principles underlying the Binet Scale and has developed an acceptable method of standardizing single tests in a scale of the Binet-Simon type. He fails, however, to apply his method to the *combination* of several tests in a year group. This is a problem not merely of determining probabilities in the single tests but of probabilities in the *combined* tests. Such combination is of course affected by the correlation between the tests combined. This is an indispensible second step which must be taken if the problem is to be solved in its entirety.

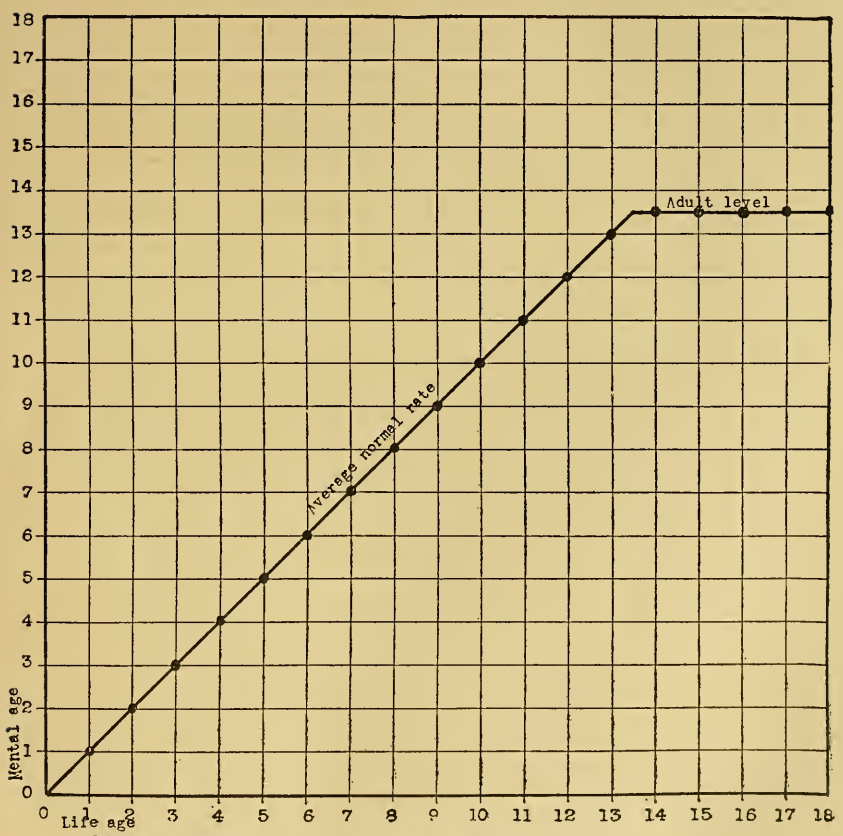
Binet and Simon were satisfied to standardize their single tests on the criterion of a majority of 'passes' for the age at which the test was considered standard. They failed to relate this to the number of passes at preceding and succeeding ages, which necessity is emphasized by Otis. Binet and Simon also failed to calculate the percentages of combined tests passed at given ages.

Most attempts to standardize the Binet Scale are based on a criterion which locates the individual tests of the Scale at the year where approximately 75 per cent of subjects pass the test. Stern (28) concludes that there is no logical justification for using this '75 per cent of passes' as a criterion for locating single tests, and accepts it solely on the ground that 'it works.'

Terman in effecting the Standard Revision cuts the knot by frankly stating (30, p. 54): "We had already become convinced, for reasons too involved for presentation here, that no satisfactory revision of the Binet Scale was possible on any theoretical consideration as to the percentage of passes which an individual test ought to show in a given year in order to be considered standard for that year." He decided (p. 53) that: "The guiding principle should be to secure an arrangement of the tests and a standard of scoring which would cause the median mental age of the unselected children of each age group to coincide with the median chronological age." This method of Terman obviates the difficulty of combined tests but ignores the problem of properly locating the single tests. Yet this problem cannot be ignored, and it appears from Terman's tables of standardization statistics (31) that he did locate the single tests according to the general principle employed by Binet.

The writer has himself experimented with several methods of standardization (11) and has presented statistics on the percentages of subjects, both normal and feeble-minded, who pass various combinations of tests, thus obtaining direct measures of the probabilities of passing single tests and various combinations. This yields not only median age distributions comparable to those of Terman but also yields a measure of 'scattering' or range of tests passed.

When experimentally standardized, by whatever criteria, the Binet Scale is expected to yield results such that the median mental ages will correspond to the median life ages when the subjects are unselected. This is, of course, an arbitrary empirical curve of growth in which the relative values of the mental age units for different parts of the scale are not known. It is based on the arbitrary assumption that increments in mental age from year to year are equal in amount, one year of mental age corresponding at all points to one year of life age up to the age-limit of growth. This curve of growth is of the form shown in Fig. 1. Its equation is $y = x$ up to $x = 13.5$, where the age-limit of 13.5 years is assumed as the life age when growth is complete.

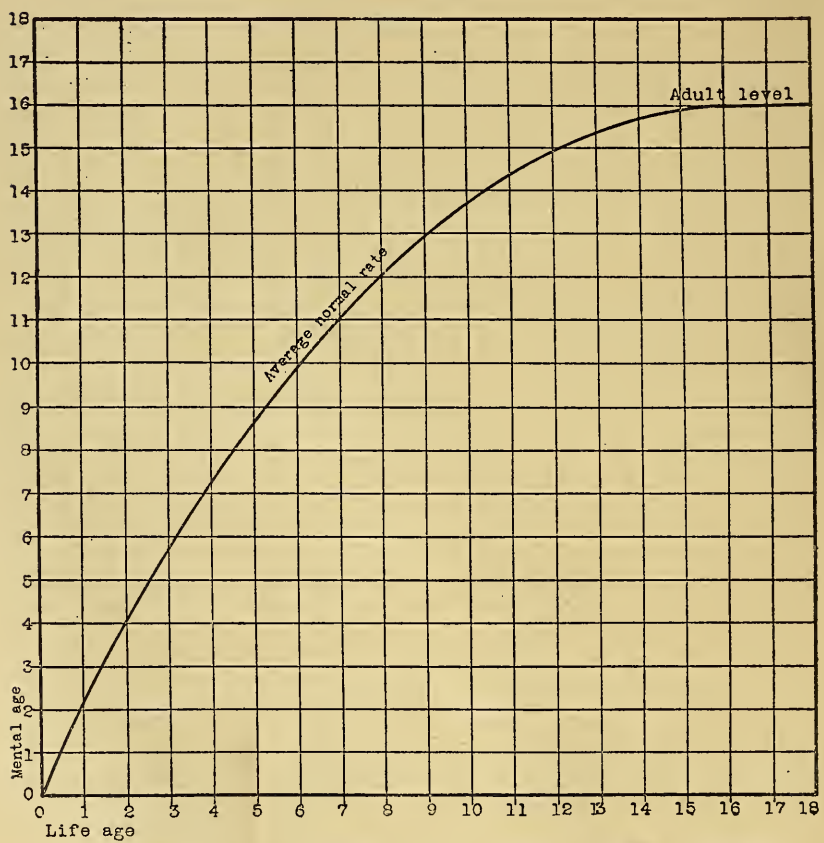


Mental age growth curve of average normal intelligence.

FIG. 1

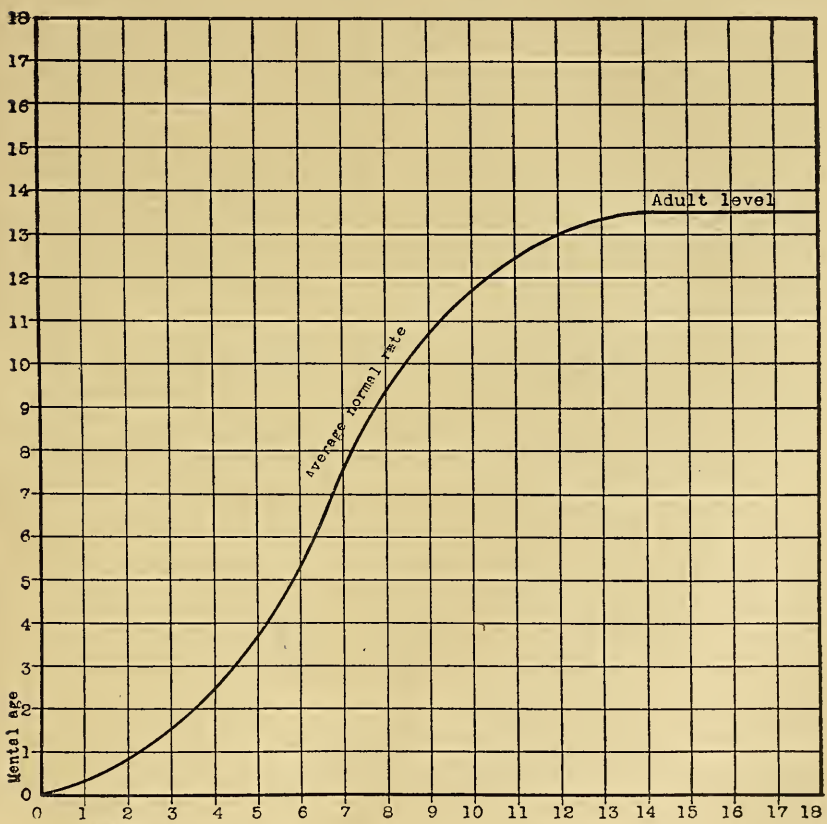
It is commonly accepted that the true curve of mental growth, plotted in equal units of absolute mental age increments (as opposed to the relative or empirical units of Fig. 1) is of the general form shown in Fig. 2. This is because of the general assumption that the true curve of intellectual growth is similar in form to the growth curves of physical development (such as height, weight, brain weight or nearly any physical trait). It is also argued by analogy with the growth curves of development in sensory and motor functions.

But careful theoretical consideration of experimental and observational child study strongly suggests a slight yet important modification of the form of curve represented by Fig. 2, if by



Traditional theoretical growth curve of average normal intelligence.
FIG. 2

general intelligence we mean a general capacity for adaptation to new situations. This adaptive capacity seems to develop very slowly in early infancy as is witnessed by the very small number of intellectual acts performed by infants. The number and diversity of these acts increase very slowly in the first few years of life. They *seem,* however, to increase rapidly because each slight increase is a tremendous *relative* increase. It seems that infancy is a period of intellectual germination rather than growth. Growth itself does not go rapidly forward until early childhood, say about 4 years of age. Then growth proceeds rapidly, following nearly a straight line course until adolescence, after which its rate is rapidly retarded until the age of final arrest at a point



Modified theoretical growth curve of average normal intelligence.

FIG. 3

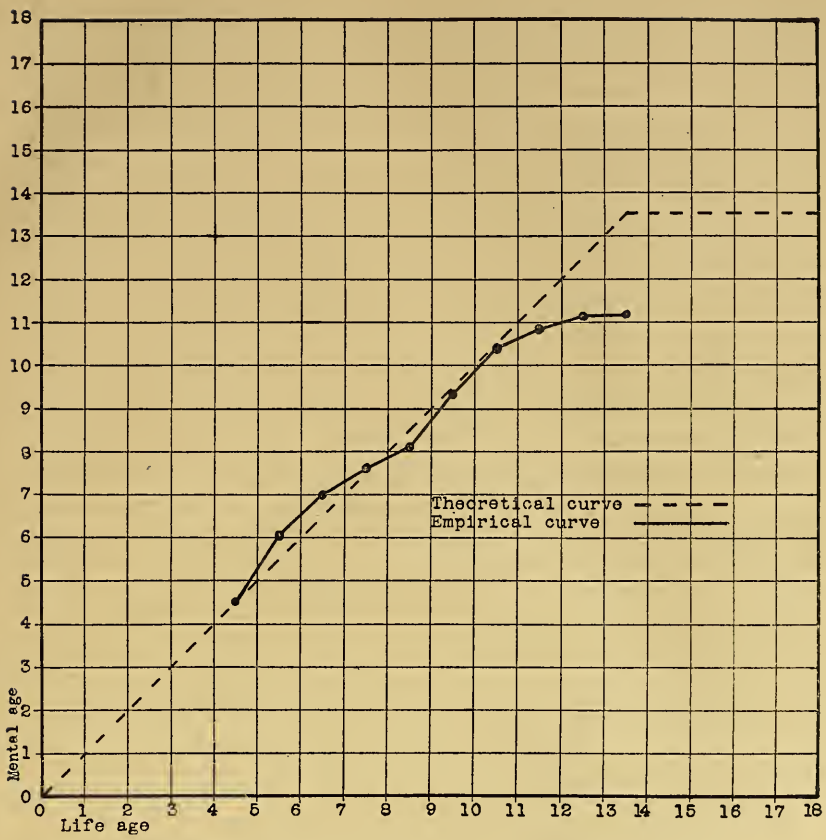
which is as yet indefinitely determined but is probably not higher than 14 years of age. On these presumptions and assuming these approximate age-points we may plot a 'true' curve as in Fig. 3, which is a modification of the curve in Fig. 2.

Whatever the exact form of the true curve of intellectual growth may be is only of passing interest for this study. For present purposes we must adhere to the general form of curve represented ideally in Fig. 1. Two principal applications of the Binet Scale (18, 31) to large numbers of subjects yield curves which approximate that shown in Fig. 1. It is interesting to note that one of these studies used a form of the Binet Scale where the single tests of the Scale were located by the criterion of 75 per cent of passes at a given age. The other ignores this principle and seeks directly to obtain median mental ages which correspond as closely as possible to the median life ages. Yet by either method the result is much the same within the efficiency limits of the two scales.

In 1911, Goddard reported his results of applying a slightly modified form of the Binet 1911 Scale to 1597 school children. The median mental ages in relation to median life ages (ages taken to last birthday) as calculated from Goddard's Table 1 (18) are shown in Fig. 4.

It will be observed from Fig. 4 that while the Goddard Scale gives on the whole an empirical straight-line growth curve of the general equation $y = x$, yet the steps are slightly unequal. This may have been caused by errors in the location of the individual tests, or by selective influences governing the nature of the subjects at the several ages. That the calibration of the Scale is inaccurate in both the ways here suggested will be showed later.

Terman has revised and extended the Binet Scale. This revision has been applied to 1,000 primary school children. Particular care was exercised in obtaining standard conditions and unselected subjects. Terman does not present a distribution table showing the mental ages distributions at each life age. He gives instead a graphic presentation of intelligence quotients (mental ages divided by life ages) for each age group (ages taken to within two months of each year-period). Calculations of median

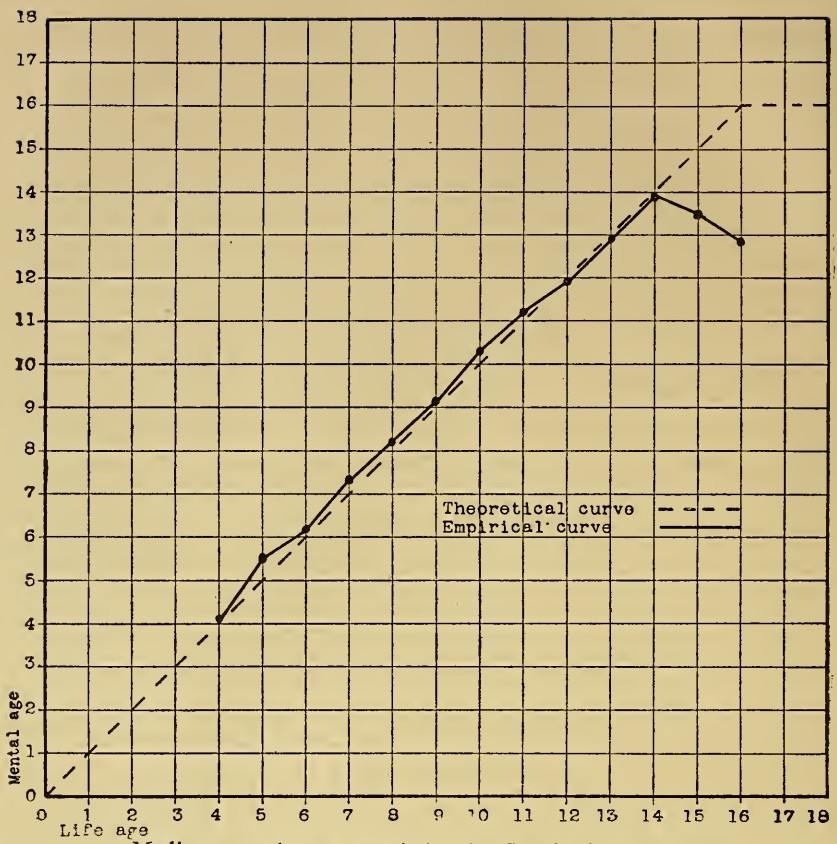


Median mental age growth by the Goddard Binet Scale.
FIG. 4

1. Q.'s[2] made from these graphs (31, pp. 33 to 38) enable us to plot Terman's results as in Fig. 5. This yields an average growth curve of intelligence which is a very close approximation to the ideal curve of this character as shown in Fig. 1. To obtain this effect, however, was the guiding principle of the standardization, namely, "to secure an arrangement of the tests which would cause the median mental age of the children of each age-group to coincide with the median chronological age."

It is of interest to note that the Goddard Scale gives an empirical growth curve which is in general similar to that of the

[2] Intelligence quotients.



Median mental age growth by the Stanford Binet Scale

FIG. 5

Stanford Scale. This is in spite of the fact that the Goddard Scale was the first experimental study of its kind on a large group, and that Goddard purposely avoided all but the most necessary re-locations of tests in the Scale in order not to effect a serious revision. It is of additional interest that the Goddard Scale, standardized on principles of locating the individual tests, gives essentially the same results as the Stanford Scale, which disregards this principle and deliberately adjusts the Scale until it has forced the median mental ages to correspond to the median life ages.

It will be noted that the curves presented in Figures 4 and 5

reach final levels. In Fig. 4 the level is reached at 10 years of life age. This is because by the Goddard Scale it was not possible to obtain a mental age score greater than 13. Indeed, a mental age score of 13 by this Scale was unusual because of certain imperfections in the tests that one could pass above the level of 12 years. Hence the upper range of possible deviations in intelligence after about 10 years cannot register themselves by the Goddard Scale. It has, however, long since been pointed out that the Goddard Scale is not a valid measure after 10 years of mental age (12).

Similarly, by the Stanford Scale the final level of intelligence is reached at 14 years of age. Terman, however, believes that his 15-year and 16-year subjects were of sub-average intelligence, because they were over-age for the 7th and 8th grades. He further believes that the true average level is about 16 years, this being the median mental age of 32 high school students and 60 business men. In accounting for this 16-year level Otis (27, p. 137) asserts as a fact that, "the number of 17-year-olds, 18-year-olds and 19-year-olds who exceed 16-year intelligence is practically the same as the number of 16-year-olds who exceed it" and that "this suggests that while intelligence increases with age, the increments decrease with age, and that after about the age of 16 years the intelligence does not increase at all, or but very little." Terman says (30, p. 140); "Native intelligence, in so far as it can be measured by tests now available, appears to improve but little after the age of 15 or 16 years. Although the location of this point is not exactly known, it will be sufficiently accurate for our purpose to assume its location at 16 years."

In opposition to these views we venture the same explanation of the assumed 16-year level by the Stanford Scale that we have just offered (and is commonly accepted) as the explanation for the 10-year level by the Goddard Scale. That is to say, the range of tests above the 16-year level in the Stanford Scale is so narrow and their nature so questionable that individual differences are not brought into display after this level. Hence, the 16-year level is the 'efficiency limit' of the Stanford Scale. There is reason

to believe that the true age of average arrest of mental age growth is actually between 13 and 14 years as indicated in Fig. 5.

Results from the psychological examining in the army and other data (*cf.* 6) suggest that the level of the true average adult is midway between the 10-year level of the Goddard Scale and the 16-year level of the Stanford Scale.

It is evident that Terman's 62 adult subjects (31) were selected in favor of superior intelligence on the basis of education or occupation. An average adult group to be unselected must include the gamut of occupations from unskilled labor to high professional skill, and the gamut of education from illiteracy to college education. These groups must be weighted according to the frequencies in each class. But Terman's adult subjects whose median mental age was 16 years were 30 successful business men and 32 high school students. Both groups are of superior selection, the one by occupation and the other by education. Terman's grammar school groups whose ages were 15 and 16 years did not exceed the median mental age of 14 years. The fact that they were over-age for this grade does not mean they were of sub-average intelligence unless they were also below the 7th school grade. Statistics of school retardation indicate that less than 50 per cent of all pupils who enter school pass beyond the 7th grade. Hence those who do go beyond the 7th grade are the supra-average individuals. If 7th grade schooling corresponds to 13-year intelligence, and if the average individual does not pass beyond the 7th grade, then the average individual has 13-year intelligence (assuming perfect correlation and equal educational opportunity).

Or we may obtain the true median mental ages for 15 years and 16 years by combining the medians of those subjects of these ages who are in high school with those who are in the grammar school. This would yield median mental ages of about 14 years for these age-groups.

In a later work Terman presents the results of several studies of the relation of intelligence to occupation (29, pp. 268-290). Median mental ages are given as follows (p. 286): college students 17.4 years, business men ("of moderate success and limited educational advantages") 16.3 years, express employees 15.2 years, motormen and conductors 13.8 years, firemen and policemen 13.4 years, salesgirls 13.6 years, hoboes and unemployed 14.2 years. The median intelligence of common laborers and unskilled workers is presumably under 13 years. Hence a representative or totally unselected or random sampling group of adults weighted according to the occupational distribution of the country at large (with larger numbers in the lower classes) would give a median mental age or average adult level of intelligence presumably not higher than about 13 years. This is exactly what was found from psychological measurement and investigation in the army, where the median mental ages of nearly 1,500,000 unselected recruits was found to be about 13 years (*cf.* 6).

We may conclude, then, that the average normal curve of intellectual growth obtained by the Binet Scale is a straight line

of the equation $y = x$. By the Goddard Scale this equation is approximately satisfied up to the point where $x = 10$, that is up to a mental age of 10 years. By the Stanford Scale the equation is satisfied with somewhat closer approximation up to the point where $x = 16$. But the average adult level of intelligence is only between 13 and 14 years according to the best available evidence. This latter conclusion challenges the validity of the standardization of the Stanford Scale beyond the age of 14 years in terms of the intelligence of the average individual. For if it is a fact that the intelligence of the average normal individual reaches a final level at 13 or 14 years of age, then the average intelligence of unselected subjects at 15, 16, 17, 18 and 19 years must be the same as that 13 or 14 years. Hence the standardizing of tests by year-intervals after ages 13 or 14 must be accomplished by some statistical device other than that employed for the Stanford Scale.

Subnormal growth of intelligence.—The growth curves of intelligence for subnormals are dependent upon the specific rate of growth and the specific age of final arrest which characterize the specific type and degree of subnormality. For normal subjects the rate of growth is on the average constant at 1.00. This is a necessary consequence of the empirical nature of the Binet Scale which we have seen is so devised as to yield median mental ages which are equal to the median life ages of the subjects on whom the scale is standardized. And for normal subjects the age of final arrest is that age at which the curves of distribution for superior ages coincide. This age may be 15 or 16 or higher, but for reasons given may be placed provisionally at 13 years.

Age of arrest for subnormals.—In a previous publication (6) the hypothesis was developed that the age of final arrest is approximately identical, on the average, for widely different mental and social types, and is so independently of the level of final arrest. This *age* of arrest was found to coincide with the *level* of arrest of the average adult, which was provisionally placed at 13 years.

We shall now on theoretical grounds take certain exceptions to this hypothesis that the age of arrest is independent of the

level of arrest and later question both theory and hypothesis by the experimental data of this study. Our theory is most clearly expounded by a consideration of the extremes of intelligence deviations.

Experience with institutional feeble-minded strongly suggests that for this type of subnormal intelligence the age of intellectual arrest is a function of the final degree of subnormality. Observation leads one to believe that idiots are arrested in their intellectual growth very early in life (say at about the life age of 5 or 6 years), that imbeciles are arrested at a somewhat later age (say about 10 or 12 years), and that morons are arrested still later (say about 15 years).

Several years ago Goddard concluded that the feeble-minded, in the majority of cases, were at a stage of arrest when they had become four years retarded mentally, that is when mental age was four years behind life age (17). He found only 6 per cent of 252 feeble-minded subjects (defined by him as those who are 4 years retarded) gaining more than 1.0 year after three annual examinations (a two-year period). These were all 'younger cases' and some 'receiving special treatment.'

Binet and Simon raised the question early in their work. After mentioning the lack of knowledge, the need for experiment and the difficulty of obtaining data, they say (2, p. 143); "No doubt it is possible—perhaps even probable—that a child who at five years has scarcely the intellectual level of a child of two, will be the same at ten or fifteen years. Without doubt one can suppose that the cerebral defects which have thus far prevented the acquisition of ordinary ideas, would remain a definite obstacle. But we have no right, without the facts, to affirm this."

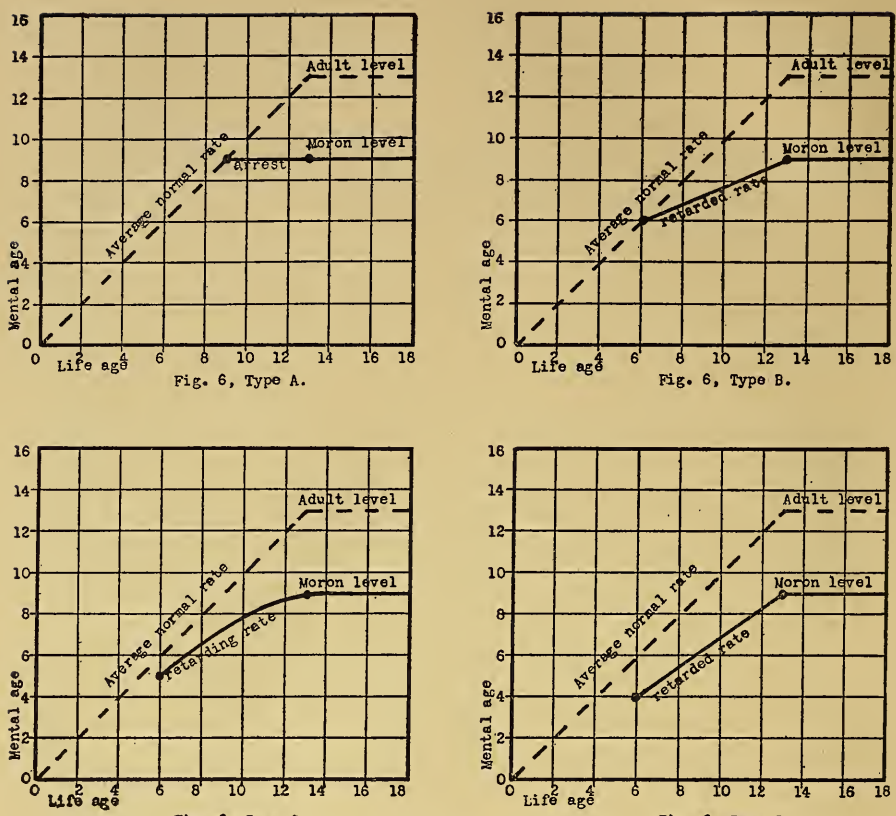
Likewise Stern says (28, p. 84): "The feeble-minded child . . . reaches a stage of arrest at an age when the normal child's intelligence is still pushing forward in its development."

Terman (29), on the other hand, maintains that mental growth develops at a constant rate for all degrees of brightness and dullness (except idiots and low-grade feeble-minded) and makes no reservations regarding the age of arrest for the feeble-minded. He calculates the relative intelligence of feeble-minded subjects on the same age-limits as for normal subjects.

Kuhlman (22) also after long experience with the institutional feebleminded assumed that all types of feeble-mindedness (except perhaps idiots) reach their level of final arrest at 15 years of age, without regard to the several degrees of defect.

The writer has previously speculated on the same subject (9) at which time he suggested that the age of arrest was reached when the mental age retardation amounted to either 6 years or was 50 per cent below life age. In conclusion it may be said that the question has never been decided on the basis of sufficient evidence.

The rate of growth for subnormals.—Not much more is known about the *rate* of mental growth among extreme subnormals, like the feebleminded, than about the age of arrest. In this regard we are even at a loss for adequate observational data. Experience with institutional feeble-minded, however, suggests a great variety of possible forms of retardation curves. Such experience points to a small but significant group of feeble-minded who grade 'at age' by the Binet Scale when first examined but who make no material progress in later examinations over a period of years (Type A, Fig. 6). There are others (Type B, Fig. 6) who at the time of first examination test at age, then continue to develop at a retarded rate for a time and then reach a point of arrest. There is a third group (Type C, Fig. 6), already retarded when first observed, who from the first examination to the age of final arrest develop at an annual rate of growth which is a constantly decreasing variable. There is also a fourth group (Type D, Fig. 6) who from the time of first examination to the age of final arrest develop at a constant rate up to the age of arrest. There are many variants and combinations of these basic types for individual subjects. We believe, however, that these four types comprise the majority of the feeble-minded. It is conceivable, though not probable, that some individuals might have a higher than average rate before retarding. It is also conceivable, though not likely, that the arrest might be relatively greater in the early ages with a curve of growth which would be accelerating at some intervals. It remains for experimental investigation to show the relative frequencies of these different



Theoretical growth curves of individual feeble-minded subjects.
FIG. 6

types of growth curves. Our own data contribute to this end, in consequence of which we shall be able to plot a number of individual growth curves of feeble-minded subjects covering a fairly long period of years (*cf.* Figures 12 to 15, pp. 107 to 118).

It is interesting to compare these observations with the opinions of other writers.

Binet and Simon anticipated this problem as they did so many others arising from the use of their Scale. They say (2, p. 143): "It is necessary to follow individually very many subjects in their development, to see if the states of intellectual inferiority are caused by arrested development, or by very slow evolution continued irregularly or intermittently, or to see if some essential faculties could increase while others remained stationary or undeveloped." There is a suggestion in their work not only of the contrast

between suddenly arrested development (our Type A, Fig. 6) and gradually increasing retardation (our Type C, Fig. 6), but also the hint that there may be some relation between the character of growth curve and the etiology of the subnormality. They were also of the opinion at that time (1905) that the course of growth was not predictable.

Goddard raised the question again in 1913. He says (15, p. 125): "How does the child reach his point of arrested development? Is it by a gradual slowing down or by a sudden stop? . . . Perhaps it is a matter of the individual. Some develop one way and some another. . . . There are some indications, however, that some children are pretty nearly normal until about eight or nine or ten years of age, and then they stop rather suddenly. . . . Others seem to have always been a little backward, but keep getting more and more backward until the age perhaps of nine or ten, when they seem to have entirely stopped."

In a later work (16, p. 61) Goddard says: "Experience has proved that these cases have a slowing down period of probably from one to three years. Moreover the slowing down process may begin at any time during childhood. Of course, with the idiot the matter is relatively quickly settled; with the imbecile less quickly and with the moron it becomes a problem for a number of years. . . . It does not appear likely that all such defectives have the same rate of slowing down; some probably reach the stopping point more quickly than others, just as some begin the slowing down process at an earlier age than others." Individual growth curves are presented in support of the argument.

Stern, generalizing from Binet, states the following thesis (28, p. 72): "For every feeble-minded child there is a level which, once attained, represents a definite terminus for his capacities to meet the demands of mental tests." He then examines this thesis in an endeavor to discover *when* the terminus is reached and *how* (that is, by what course) it is reached. He sharply distinguishes *arrest* from *retardation,* the criterion of the former being the arrival at the terminus and the criterion of the latter being the process of reaching the terminus. Concerning the rate of growth he says (p. 79): "Since feeble-mindedness consists essentially in a condition of development that is below the normal, the *rate* of development will also be a slower one." From these premises Stern develops the 'intelligence quotient' as a means of measuring relative retardation and rate of growth. He says in regard to this quotient (p. 83): "The quotient does not seem, however, to afford an actually constant expression of degree of feeble-mindedness, but *shows a tendency to fall in value as age increases.*" And further: "The above-mentioned gradual tendency of the mental quotient to sink during the progress of development shows that this development approaches the final level of arrest at a progressively decreasing rate."

Bobertag is credited by Stern as "laying special emphasis on this progressive rate of retardation in the development of the feeble-minded" and as attempting to express it graphically. (We shall subsequently present a detailed analysis of Bobertag's position.)

Kuhlmann (22) conceived the idea of an intelligence quotient about the

same time as Bobertag and Stern. His material led him to the assumption that the rate of feeble-minded growth is constant throughout the developmental period and up to 15 years of age for any given degree of feeble-mindedness except idiocy. But he recognizes that this assumption holds only for the averages and might be found invalid for individual cases. He cites the possibility of an increasingly retarded rate in particular subjects.

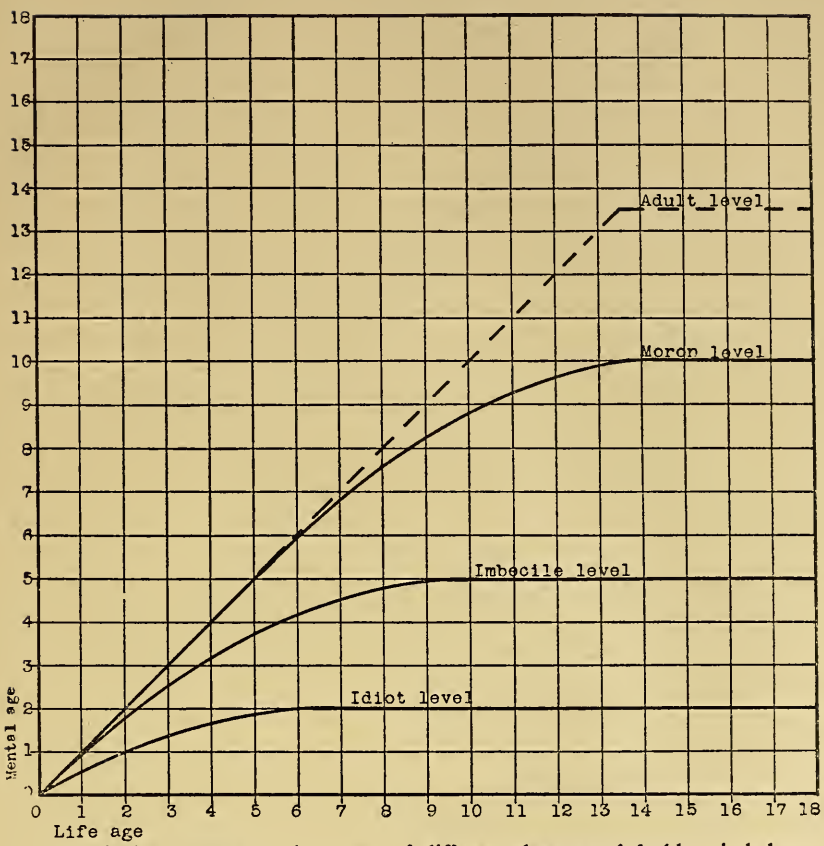
There is a growing body of literature which deals with the rate of development from the standpoint of intelligence quotients. In a succession of important studies since 1915, Terman has consistently argued that intelligence quotients tend to remain constant. This point of view is critically analyzed in a later section.

The writer has himself previously contended that the rate of development among individual feeble-minded subjects is exceedingly variable and non-predictable (9). The fact that some feeble-minded develop at a normal rate early in life and then rapidly slow down in development (at about eight or ten years of age) has led the writer to recognize a condition of 'potential feeble-mindedness' (8, 10), a clinical type of feeble-mindedness in which intelligence retardation is not observable at the time of diagnosis, yet where the diagnosis is upheld by the subsequent history of the individual.

From this review of the field we find some difference of opinion. It may be well to suspend judgment for the present. The experimental evidence of the present investigation is intended to throw light on this problem, which is of fundamental interest in mental diagnosis.

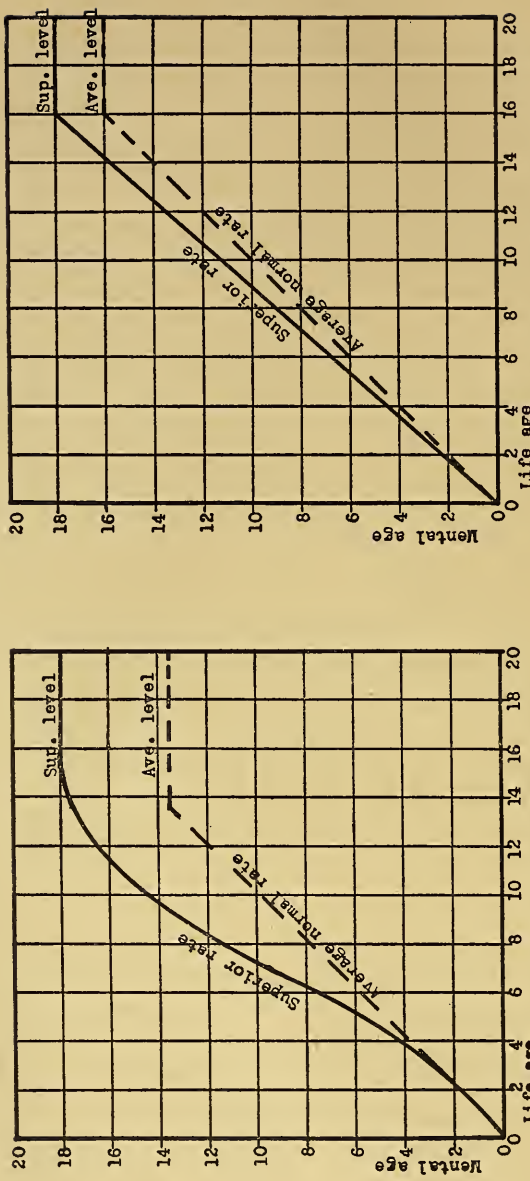
Logical considerations lead to the belief that the *age* of arrest and the *rate* of retardation are both functions of the *level* of arrest, on the average at least. Psychological and logical considerations indicate that for the feeble-minded it is probable that the rate of growth is a decreasing variable. This will not prevent us from admitting, however, the possibility of many kinds and degrees of individual variation. Theoretical curves based on these logical and psychological considerations are given in Fig. 7.

Supernormal growth of intelligence.—We may now apply the same general argument as developed above to the question of growth curves of supernormal deviations in general intelligence. On *a priori* grounds it would seem that persons of superior intelligence tend to become increasingly superior, that is, they tend to develop at a rate of growth which is an increasing variable. If (1) the intellectually subnormal develop at a regularly decreasing rate; and if (2) the average unselected rate based on a



Theoretical average growth curves of different degrees of feeble-mindedness.
FIG. 7

composite of subnormal, average normal and supernormal is constant at all ages; and if (3) there are as many supernormals as subnormals; then it is highly probable that the decreasing rate of the subnormals must be offset by an increasing rate for the supernormals. Otherwise the decreasing rate of the subnormals would in some degree affect the constancy of the total average rate for all unselected subjects. The only other possibility is that the decreasing rate of the subnormals is offset by an increase in the *number* of supernormals rather than in the *rate* for supernormals. This is a tenable hypothesis, for if some subjects of 'at age' intelligence are potentially feeble-minded it is certainly



Type B.—Assuming a constant rate of growth and an adult level of 16.

Type A.—Assuming an accelerating rate of growth and an adult level of 13.

Theoretical average mental age growth curves of superior children.
FIG. 8

also likely that others are potentially gifted. But since the percentage of average normals must remain constant (being by definition the middle 50 per cent of all cases) it is more likely

that the decrease in rate of subnormals is actually compensated for by an increase in the rate of supernormals.

There is, however, very little basis of fact on which to base speculations regarding the rate of growth of gifted children. Very few experiments have been made on a large scale. We need long-time studies of individual re-examinations. Terman, however, comes to the conclusion that the rates of development of superior children are constant just as he finds they are constant for average normals and subnormals. Miss Gillingham, however, one of the few other students who has made re-examinations of superior children, finds her subjects quite variable, some increasing and some decreasing. We shall examine these points of view more carefully in a critique of intelligence quotients and by some new experimental evidence. For the present we may content ourselves with two probable hypotheses, (1) that the rate of growth of superior children is an increasing variable, the growth curve following the general form of Type A, Fig. 8, or (2) that the rate is constant throughout the development period, the growth curve being of the general form of Type B, Fig. 8.

II. EXPERIMENTAL INVESTIGATION

Having defined our terminology, stated our point of view and advanced certain theoretically developed hypotheses, we may now pass to the justification of these hypotheses in the light of experimental evidence. Our major experimental study is based on ten years of re-examining feeble-minded subjects of all ages, mental ages and degrees of relative retardation. Our minor experimental study is based on three years of re-examinations of superior children between the ages of 9 and 13 with I. Q.'s of at least 110 at one or more of the examinations.

A. Feeble-Minded Growth

History of the experimental data.—The Binet-Simon tests were introduced into this country about 1908-1909. At that time, Dr. Henry H. Goddard, Director of Research at The Training School at Vineland, N. J., employed the 1905 series of tests as a means of classifying the feeble-minded 'children' at the Training School. In 1910, the 1905 series of tests was replaced by the Binet-Simon 1908 Scale (13) which was applied systematically to all inmates of the Training School. The results were so remarkably superior to those which had been previously obtained by the limited technique of mental tests then in use and were found to correspond so closely with all other experience with these feeble-minded that the 1908 Binet Scale was made the basis of classification and grading at the Training School (*cf.* 14).

Goddard immediately foresaw the great value of the Binet Scale as a means of measuring the mental 'improvability' or intellectual growth of the feeble-minded. He accordingly provided for annual re-examinations of his subjects. At the same time he proceeded to correct certain inaccuracies in the method by standardizing the 1908 Scale on a large body of American school children (*cf.* 18). This standardization of the Scale proved to be sufficiently accurate for all practical purposes and became the fundamental psychological method in use at The Training School

from 1911 to 1916. This form of the Binet Scale was continued as the examining method for measuring growth of intelligence for the subjects of this experimental study until Dec. 1919.

The data of this experimental investigation are based on the results obtained in 1910 by Goddard's translation of the Binet-Simon 1908 Scale, and between 1911 and 1919, inclusive, by the so-called Vineland Revision, or Goddard Revision of the Binet Scale (13).

There is some objection to including the 1910 test-records in this investigation. There is sufficient difference between the two scales used to warrant an objection to the validity of comparing the resultant mental ages. Nevertheless it is desirable to retain these very early records for the sake of the long time-interval they afford between first and last test-records. Moreover, the discrepancy between the two scales is not, after all, of much practical consequence, since the mental ages by the two different scales are closely similar.

In order to preserve these early records and yet maintain uniformity of material all 1910 records have been transcribed in terms of the Goddard (1911) revision. This transcription of course affects many of the single tests of the 1910 examinations, since some of the tests of the 1908 Goddard Scale are excluded from the 1911 Goddard Scale. Other tests may not properly be transcribed from one Scale into terms of the other because of modification of procedures either in administering or scoring the individual test. All such tests, namely those of the 1908 scale which do not appear in the 1911 scale at all or else appear in modified form, have been excluded from the final data.

These transcribed records were in consequence of these difficulties sometimes incomplete. If the incompleteness was so great that it could not safely be made good by means of certain rules (to be discussed presently) for scoring incomplete tests, then the entire test-record for that year was discarded. If, however, the incompleteness could be provided for under those objective rules for scoring incomplete records, then the scores for the omitted single tests have been supplied under those rules, as will be explained.

An additional and more serious factor leading to the incompleteness of 1910 records is found in the narrow-range method of testing employed during those years. This also has been overcome by the use of objective rules for scoring incomplete examinations.

The data have been collected by a large number of different examiners. The examinations during 1910, 1911 and 1912 were made principally by Dr. Goddard's assistants carefully trained in the method. During these years an attempt was made to examine the entire number of children residing at The Training School. The results of these repeated examinations were reported by Dr. Goddard (15, 17) in 1912 and 1913.

Goddard appreciated the preliminary nature of his investigation and recognized the need for study covering a longer period of time. It is to his good judgment and foresight in this regard that we owe the collection of data upon which this present report is based. The personal direction and analysis of these continued examinations was, in 1913, assigned to the present writer as his major routine duty as assistant to Dr. Goddard. Accordingly the collection of data for the present study was entirely in the hands of the writer after 1912, except for such examinations as were conducted during the annual Summer Schools held at The Training School. These latter examinations were conducted under the immediate supervision of Dr. Goddard, Dr. F. Mateer, Dr. S. C. Kohs and Dr. C. T. Jones during successive summer periods.

After 1912 an attempt was made to regulate the time-interval between re-examinations by establishing a calendar file of records. Provision was made for re-examining new cases one month after admission to The Training School and for re-examining twice a year all children under 15 years of age. All examiners were carefully trained in the method before their results were admitted to record. Apparatus, technique and standards of scoring were minutely standardized. Wide-range testing was demanded in all records. The work of unskilled examiners was closely supervised. Summer school records were labelled as such and unless approved by the supervising instructor were not ad-

mitted to the data of this investigation. In all examining it was considered a prime duty of the examiner to secure a favorable attitude.

From this it will appear that the data are somewhat subject to minor inaccuracies on the ground of examiners' personal equation. Goddard has reported an influence of personal equation (17), but is of the opinion that personal equation is of little significance among mental defectives who are retarded four years or more. Brigham also (5) has studied personal equation with minute accuracy, and is of the opinion that while personal equation is evident on single tests in the Scale it is imperceptible in the total mental ages. This imperceptibility is presumably due to compensating influences in the single tests, variability operating in favor of the subject on some tests and against him on others. In general it may be said that personal equation is a complex of variations in apparatus, technique of administration and of scoring, personality or attitude of subject and examiner and consequent *rapport,* and various internal and external additional factors influencing both examiner and subject in varying degrees at different times, such as time of day, pleasantness or unpleasantness of atmosphere or physical surroundings, presence of observers, physical well-being, need for haste, pre-judgment of the subject's mentality, skill in 'handling' the subject or in manipulating the method, and so forth *ad finem.* Most of these influences are not subject to measurement and among mental defectives are either negligible or tend to offset each other.

Special objections might also be raised against the use of Summer School data on the ground of specific inaccuracy. In answer to this objection we may refer to the experimental studies of Kohs (21) and Martin (24) which demonstrated that for at least the School where these data were gathered the mental ages obtained by Summer School students after six weeks of intensive training and supervised examining are safely comparable with those obtained by highly skilled examiners.

Description of data.—The inmate population of The Training School approximates 500. There is an annual change in population amounting to perhaps 100 new admissions to offset dismissals, releases, transfers and deaths. From 1910 to 1917 approximately 1,000 patients have been examined and re-examined. No new cases were examined for the purposes of this study since 1916. This group of about 1,000 is cut to about 400 when we eliminate those subjects who were not examined at least two or three times.

About 1913 the writer instituted a procedure of transferring the records of examinations from the Binet record sheets to summary cards. These cards were designed to show the plus and

FIG. 9

Specimen summary card of repeated Binet examinations*

(Name) Elmer H----- (Born) 8/10/03 (Received) 3/26/13

Examiner	Date	Score	M.A.	L.A.	I.Q.	Retard.	VII	VIII	IX	X	XI	XII
Mateer	3/27/13	9^{3}	9.6	9.7	99	.1	+ + + + +	+ + + + +	+ + + + +	+ + - - -	- - + - ⊖	⊖ ⊖ ⊖ ⊖⊖
Mateer	4/26/13	7^{11}	9.2	9.8	94	.6	+ + + + +	+ - + + +	+ + - + +	+ + - - -	- - - + -	⊖ ⊖ ⊖ ⊖⊖
Petersen	7/18/13	8^{6}	9.2	9.9	93	.7	+ + + + +	+ + + + +	+ + - + -	+ + - - -	- - - + -	⊖ ⊖ ⊖ ⊖⊖
Doll	9/22/13	7^{13}	9.6	10.1	95	.5	+ + + + +	+ - + + +	+ - + + +	+ + + - -	- - - + -	+ ⊖ ⊖ ⊖⊖
Kohs	7/29/14	6^{15+}	9.1	10.9	84	1.8	+ - + + +	+ - + + +	+ - - + +	+ + - - +	- - ⊕ + -	⊖ - ⊖ - -
Gray	2/26/15	8^{9}	9.8	11.5	85	1.7	+ + + + +	+ + + + +	+ + - + +	+ + - - -	- - + + -	⊖ - - - +
Crafts	2/20/16	8^{11}	10.2	12.5	82	2.3	+ + + + +	+ + + + +	+ - + + +	+ + - - +	- - + + -	⊖ - - ++
Hemphill	8/7/16	8^{9}	9.8	13.0	75	3.2	+ + + + +	+ + + + +	+ - + + +	+ + - - +	- - - + -	⊖ - - - +
Lindley	3/12/17	8^{10}	10.0	13.7	73	3.7	+ + + + +	+ + + + +	+ - + + +	- + + - +	- - + + -	- - - - +
Whitmore	8/17/17	7^{10}	9.0	14.0	64	5.0	+ + + + +	+ + + - +	+ - - + -	- + - - +	- - - + +	- - - - -

* The encircled symbols indicate test scores which have been supplied under the objectives rules.

minus responses to the individual tests on repeated examinations. A specimen card is shown in figure 9. This card shows the name of the subject, the date of his birth, and the date of his admission to The Training School. The successive columns from left to right show the name of the examiner, the date of examination, the 'basal year' and additional number of tests passed in the examination, the mental age, the life age, the intelligence quotient, the amount of retardation, and then the succession of reactions in the Goddard arrangement of the Binet tests.

All data transcribed from original record sheets to these cards were carefully checked up. Wherever the original record contained material which afforded a basis for verifying the score assigned (plus or minus) such verification was made. This checking was particularly important in early test-records (prior to 1913) since the standards of scoring did not become well stabilized until toward the close of 1912. No scores were changed without evidence which permitted such changes. Records obtained by means of the 1910 Goddard version of the Scale were transcribed in terms of Goddard's 1911 version as previously described, especial care being taken in relation to modifications in technique or scoring of the individual tests.

After this card file was begun it was used as a calendar file to standardize the time-interval between tests. New data were transcribed to the cards as soon as new examinations were made. At various times the writer attempted to analyze the results. Each such attempt proved abortive owing to the exceedingly difficult nature of the material in relation to an adequate mode of presentation. The material was so heterogeneous that no satisfactory classifications of data could be devised to represent the facts clearly and simply. Moreover each attempted analysis showed an imperative need for additional material and a longer period of time. Many minor problems suggested themselves as necessary preliminaries to the final adequate analysis. The results of those minor studies have been previously published and afford support to certain arguments to be presented.

The repeated examinations of about 400 subjects formed the starting point of the present report. A close study of the ma-

terial showed the necessity for eliminating the records of certain subjects. It was decided to use no records which showed a gap of more than two years between any two successive examinations. It became obvious that records based on less than 5 annual examinations would not contribute much to the final conclusions; hence all such records were excluded. Certain special records were also rejected on the basis of special physical infirmities, such as deafness or partial deafness, seriously defective vision, motor ataxia, paralysis and the like. These rejections were made in ignorance of the significance of the data rejected,[3] and indeed of the data as a whole, since we were not at the time aware of what the results might show. Three special cases were excluded from the final tabulations, one who was 2 years old at the first examination, one whose initial mental age was 11 years, and one whose final mental age was 11 years. These were eliminated because they fell outside the age and mental age classification limits of the material as a whole; all other subjects were at least 6 years old at first examinations and were below mental age 11 years.

There remained 203 subjects. Fifty-five of these were examined at least once every year for at least 5 years; 72 were examined at least once every year but one for a period of at least 5 years; 37 showed a single gap of two years between successive examinations; 17 showed 2 gaps of single years; 18 showed 1 gap of 2 years and 1 gap of 1 year; 4 showed 3 gaps of single years. Ordinarily the total number of examinations per subject exceeded the total number of years covered by the examinations. On the average, for all subjects there was only slightly more than one examination per year. The distribution of examinations for all subjects is given in Table 1. This table shows the number and extent of gaps between examinations, the corresponding numbers of cases, the total number of examinations and the periods of time covered per subject. It will be seen that

[3] No mental ages were entered on the summary cards until after these subjects had been eliminated. The mental ages were not computed until after the individual examination records had been corrected for the errors of incomplete examining. To avoid bias we remained in ignorance of the exact mental ages until the material was ready for the final computations.

the total number of subjects is 203, and the total number of examinations 1797, giving an average of approximately 9 examinations per subject. The total number of subject-years (obtained by taking the weighted totals for the column headed 'period of years') is 1477, giving an average of approximately 7 years per subject. Dividing the total number of examinations by the total number of subject-years gives an average of 1.2 examinations per subject per year.

TABLE 1

Description of feeble-minded data showing temporal distribution of examinations

Continuity of examinations	No. of subjects	No. exams.	Period of years covered 5	6	7	8	9	10
No gap between examinations..	55	578	21	8	8	10	4	4
1 gap of 1 year.....	72	684	7	18	18	11	10	8
1 gap of 2 years.....	37	260	1	1	23	7	4	1
2 gaps of 1 year each.....	17	131	1		7	7	2	
1 gap of 1 year and 1 of 2 years	18	119			2	9	5	2
3 gaps of 1 year each..'.....	4	25			2		2	
Totals	203	1797	30	27	60	44	27	15

Correction of incomplete examinations.—Prior to 1913 the need for 'wide range' testing was not commonly recognized by those who applied the Binet-Simon Scale. Indeed the original mode of calculating mental age as advocated by Binet encouraged narrow range testing in the lower reaches of the Scale. Moreover, it has always been difficult to induce even skilled examiners to employ wide range testing. Consequently the comparison of some successive examinations is affected by differences in the extent or range of the Scale that was used in examining the subjects. In comparing repeated examinations an apparently significant gain in mental age may be only the result of a more extended examination in the upper range of the Scale, or an apparent loss may be really only a consequence of a more extended lower range of application. A mental age obtained by narrow range examining is ordinarily sufficiently accurate for practical purposes, but it may be significantly inaccurate when compared with preceding or succeeding examinations in an endeavor to discover small amounts of mental gains or losses.

This error in the original examinations threatened to limit the value of the study, for it was to be expected that the amounts of

mental age increase among the feeble-minded would prove to be relatively small. This fact made it imperative that the incomplete examination records be somehow rendered complete or that such records be eliminated from the data. The latter procedure would have eliminated much otherwise valuable material. Moreover, the error looms larger on theoretical considerations than its practical significance warrants. Hence it seemed desirable to correct the initial data by completing the incomplete examination records. This proved a peculiarly difficult yet not impossible task.

Objective rules for completing incomplete examinations.—One who is well versed in the Binet method, who knows the errors of standardization which produce improper locations of the single tests, knows the comparative difficulty of the tests for feeble-minded, knows the influences of experience and which tests are affected by practice, schooling and maturity, knows the examiners and their personal equations, and knows well the subjects and their personal idiosyncracies will not have much difficulty in correcting or completing inaccurate or incomplete Binet records of feeble-minded subjects. He will, however, always be obliged to resort to considerations which are principally subjective. He must consider such a variety of combined considerations that he is liable to give unstable judgments. He would also find such a task exceedingly fatiguing if he endeavored to complete any serious number of examinations; the conflict of evidence, the weighting of evidence and the multiplicity of factors involved demand a high pitch of concentration for successful application. But above all his judgments could readily be challenged by some other person of equal expertness and he would be unable to substantiate his judgments in a manner that would probably be convincing to a skeptic.

It was therefore a first task to devise an *objective* means of completing the original examination records. No attempt was made to correct suspected errors in scoring or recording.

The demands of the problem, then, require an objective technique for scoring those tests of the Scale which have not been

scored on some examinations but have been scored in others.[4] Since there is no demand to correct a test already scored, the rules apply only to unscored single tests. The purpose of the rules is not to decide the absolute probable score of a test as it affects the mental age of a particular examination, but is designed to determine the *comparative* probable score of a test which is sometimes not scored in a succession of examinations. The aim is to obtain a succession of mental ages which are satisfactory for *comparative* purposes and to eliminate errors which affect the comparisons. There is no concern as to the probable score of a test which does not influence the *comparative* mental ages. Hence we are not concerned about those tests which are never scored in successive examinations but only those which are sometimes though not always scored.

For these purposes the scale of tests shall be understood to cover three 'ranges' for each subject. These are:

(1). A *lower range,* which includes in each separate examination the series of tests from the lowest mental year of the Scale to the highest year (inclusive) in which all five tests for a year are scored plus.

(2). An *upper range,* which includes the series of tests (in ascending order of difficulty) beyond the first year in which less than three tests are scored plus.

(3). A *middle range,* which is the series of tests between the upper limit of the lower range and the lower limit of the upper range.

If in any of these ranges a test of the Scale is sometimes scored and sometimes not scored, then a probable score for such unscored tests is to be assigned in accordance with the following rules. The rules are to be applied in order of numerical sequence; a later rule is not to be applied if an earlier rule can be made to apply satisfactorily.

Rule 1. An examination record is to be excluded entirely as too incomplete for accurate uses if less than 5 tests are recorded beyond the highest year where all tests are recorded as plus.

[4] In this discussion "test" is used to designate a single test-problem of the Scale, while "examination" refers to an application of the Scale as a whole to obtain a mental age.

Rule 2. Year IV in the Goddard Scale has only four tests while every other year (above year II) has five. Each test at year IV has therefore a value of .25 instead of .20 as at other years. In calculating mental ages the loss of this test at year IV sometimes affects the total comparative mental age, due to a shift in the basal year. To avoid this error and at the same time provide for the slightly higher value of the IV-year tests proceed as follows:

(a). If three or four tests are scored plus in year IV, credit an extra test plus.

(b). If only two tests are scored plus, credit an extra test plus and minus (half credit, or .1 year).

(c). If less than two tests are scored plus, credit an extra test minus.

Rule 3. In the following pairs of tests (Goddard Scale) one test-problem serves for both tests of a pair and one test-reaction on the part of the subject furnishes the score for both test-locations, being automatically plus for the first of the pair if plus for the second, and minus for the second if minus for the first (plus score in the second of each pair requiring a higher type of response than for the first).

III_4 (enumeration in pictures)—VII_2 (action in pictures)

V_4 (count 4)—VII_1 (count 13)

VI_2 (define by use)—IX_2 (define better than use)

X_5 (3 words in simple sentence)—XI_2 (3 words in complex sentence).

Therefore:

(a). If the first is scored minus, the second must be scored minus; and if the second is scored plus the first must be scored plus (since failure on the first includes failure on the second and success on the second includes success on the first).

(b). If the first is scored plus, the second if unscored is presumed to be minus (since otherwise the examiner must have recorded plus for the higher form of response); and if the second is scored minus, the first if unscored is presumed to be plus (since if it had been minus the examiner must have recorded it). This rule is based on the known tendency of examiners to fail to

record plus scores in the lower range and minus scores in the upper range since such scores do not affect the calculation of mental age.

(c). If (through an obvious error of record) both tests in a pair are scored in such a way as to conflict with part (a) of this rule, the prevailing score of the test in successive examinations may be appealed to for correcting the obvious error.

Rule 4. In the following pairs of tests there is primarily a quantitative difference in the two test-problems; success in the first of the pair is generally prerequisite for success in the second (because the second also includes the specific test-problem of the first):

I_1 (visual regard)[5] — I_3 (visually stimulated prehension)

I_1 —all tests beyond I_3.

I_3 (prehension visually stimulated) — II_1 (visual discrimination of food)

I_3 (prehension visually stimulated) — II_2 (unwrapping candy).

III_1 (point to parts of body) — VI_4 (designate right and left).

III_2 (repeat 6-syllable sentence) — V_3 (repeat 10-syllable sentence)

III_3 (repeat 2 digits) — IV_3 (repeat 3 digits)

IV_3 (repeat 3 digits) — $VIII_5$ (repeat 5 digits)

V_2 (copy square) — VII_4 (copy diamond)

V_2 (copy square) — X_2 (draw design)

$VIII_3$ (repeat days) — IX_4 (repeat months)

$VIII_5$ (repeat 5 digits) — X_3 (repeat 6 digits)

X_3 (repeat 6 digits) — XII_1 (repeat 7 digits)

In applying probable scores for these pairs of tests there is a strong presumption that if the first of a pair is minus the second will be minus, and that if the second is plus the first will be plus because of psychological similarity of test-problems. There is, however, technical objection on the grounds of incomplete iden-

[5] For a description of the 1-year and 2-year tests see (2) pp. 45 ff. For a description and arrangement of the Goddard Binet Scale as a whole see (13).

tity to scoring one of the tests of these pairs in terms of the other of the pair. This objection finds support in the inconsistency of reactions sometimes showed in these pairs by epileptic or demented subjects. Yet we shall commit no serious practical error in formulating a rule analogous to part (a) of Rule 3. One might also develop a favorable argument for applying part (b) of Rule 3 to these pairs on the ground of the admitted tendency of examiners to ignore probable plus scores in the lower ranges and to ignore probable minus scores in the upper ranges. We prefer, however, to err in the direction of conservatism on this point and therefore admit part (a) of Rule 3 but exclude part (b) in scoring the pairs under this Rule 4. Therefore we state Rule 4 as follows:

If the first of the above pairs is scored minus, the second if unscored is to be scored minus; and if the second is scored plus, the first if unscored is to be scored plus.

Rule 5.—In the case of tests showing lesser degrees of dependence than the pairs listed under Rule 4 it is necessary to appeal to the usual performance or typical score in a test in a succession of examinations. In the case of the feeble-minded this criterion is fairly dependable, since there is a remarkable degree of similarity between successive examinations, not only in the gross mental ages but in the individual tests. Our rule on this point, however, may not properly be based on an assumption of such similarity, since the investigation of this alleged similarity is our fundamental problem. Hence we must formulate a rule which while it assumes a tendency toward such similarity for brief periods does not assume it for long periods of time. We cannot, in other words, afford to ignore a possible influence of age or experience which may affect the successive reactions to individual tests. We have adopted the following rule as affording a maximum of satisfaction and a minimum of objections:

(a). If in a series of examinations an unscored test is surrounded by at least three or more recorded plus scores (two before and one after, or vice versa) without intervening minus scores, such unscored test is to be scored plus. And similarly for minus.

Examples:[6] + + (+) +; + (+) + +; — (—) — —

(b). An unscored test prior to the first recorded score is to be (1) scored plus when the first two recorded scores are plus; (2) scored minus if the first recorded score is minus; and (3) scored plus and minus (half credit or .1 year) if the first two recorded scores are a plus followed by a minus; *provided* that if the upper range of tests becomes extended in successive examinations because of increase in mental age then the unscored tests which precede the initial score for that test are to be scored minus (in the upper range) regardless of subsequent pluses.

Examples: (1) (+) + +; (2) (—) — +; (3) (±) + —

(c). If in a succession of scores which are sometimes plus and sometimes minus an unscored test is surrounded by three unlike signs (two plus and one minus, or vice versa) such unscored test is to be (1) scored plus if 75 per cent or more of all scores recorded for that test are plus; (2) scored minus if less than 25 per cent of all recorded scores are plus; and (3) scored plus and minus if between 25 per cent and 74 per cent, inclusive, of all recorded scores are plus. For this section of this Rule to be operative the test in question must have been scored in at least 50 per cent of the total number of examinations. Scores supplied in accordance with Rules 3 and 4 above are to be considered as recorded scores for purposes of this Rule.

Examples: (1) + + + + (+) — + + — +
(2) — + (—) — — — + — — —
(3) + — + — — + (±) — — +

Rule 6. If a test has been scored in less than 50 per cent of the total number of recorded examinations such test is considered an 'isolated test.' Unrecorded scores of an isolated test are to be (a) scored plus if all recorded scores for that test are plus (b) scored minus if all are minus. (c) If some recorded scores are plus and some are minus, then the actual score as recorded is to be discarded and the test is to be scored (1) minus in the upper range, (2) plus in the lower range, and (3) plus and minus in the middle range, *provided* that if the lack of recorded

[6] The symbols in parentheses indicate test-scores which have been supplied under the objective rules for scoring incomplete examinations.

scores occurs in the early examinations and an extension in the upper range of tests is made necessary by significant increase in mental age, then (1) prior to the first recorded score the unscored test is scored according to Rule 7, and (2) after the first recorded score it is scored according to sections a, b and c of Rule 5.

Rule 7. Unscored tests in the lower range (of each examination) are presumed as plus, in the upper range as minus and in the middle range as plus and minus. This Rule applies only after all preceding rules have been applied.

These rules were formulated after a minute analysis of the problem. They were, with others, tried experimentally before being adopted, being checked against the more or less obvious probabilities of combined considerations. These particular rules seemed to meet all necessary considerations on a strictly objective basis and at the same time seemed to avoid any assumptions which might bias the results or introduce a constant error. Indeed, it is felt that the rules are more elaborate and specific than the nature of the error to be corrected may warrant. For it should be emphasized that the omissions were neither very frequent nor very serious. In deciding upon the rules a bias was maintained for a tendency to score minus in the upper range and plus in the lower range. Hence, there is no obscuring of significant progress. It should also be emphasized that the corrections to the gross mental ages were always slight.

The critical student may question our choice of pairs of tests listed under Rule 4. It will seem to him, according to his own analysis of the meaning of the individual Binet tests, that some tests are improperly included and that other pairs are improperly omitted. Indeed, our original list was supplemented by a second list of eighteen additional pairs of tests which seemed to contain the same fundamental psychological elements, but this second list has been omitted from our rules because of lack of sufficient identity in the test-problems. This list included such pairs as memory for sentences and memory for numbers, comparing lines and comparing weights, adding stamps and making change, and so on. In these pairs, however, the specific problems were not so similar as in our other list and the reaction to one of the pair did not include reaction to the other.

We also considered the possibility of supplying scores solely on the basis of known association of successes or failures in pairs of tests. This principle was discarded because of insufficient data and individual variability. This

criterion breaks down at the crucial places where its usefulness is most needed.

An objection may also be raised to our definition and use of 'range.' This objection would be grounded on the contention that the single tests are not properly located in the scale in order of serially increasing difficulty. This contention is further strengthened by the demonstrated fact that such an order of difficulty is not the same for feeble-minded as it is for normal subjects (*cf.* 7). While admitting the truth of these arguments we deny their force, for relocation of the tests either for normals or defectives does not cause a shift in any test of more than one year. It seemed therefore unnecessary to allow for this error. To have done so would have in any case been a very difficult matter and the anticipated results did not promise to justify the large amount of clerical work involved.

We offer these rules, then as being sufficiently accurate for their avowed purposes. They may be summarized as follows:

Rule 1. Discard an entire examination if less than 5 tests are recorded above highest year where all are passed.

Rule 2. Credit extra test at year IV:

(a). plus if 3 or 4 are plus

(b). plus and minus if only 2 are plus

(c). minus if less than 2 are plus.

Rule 3. Automatic credit in following pairs:

$III_4 - VII_2$	$VI_2 - IX_2$
$V_4 - VII_1$	$X_5 - XI_2$

(a). If first is minus, score second minus. If second is plus, score first plus.

(b). If first is plus, score second minus (if unscored).
If second is minus, score first plus (if unscored).

(c). Correct obvious error by usual performance.

Rule 4. Automatic credit in following pairs:

$I_1 -$ I_3 and above	$IV_3 - VIII_5$
$I_3 - II_1$	$V_2 - VII_4$
$I_3 - II_2$	$V_2 - X_2$
$III_1 - VI_4$	$VIII_3 - IX_4$
$III_2 - V_3$	$VIII_5 - X_3$
$III_3 - IV_3$	$X_3 - XII_1$

(a). If first is minus, score second minus (if unscored).

(b). If second is plus, score first plus (if unscored).

Rule 5. Usual performance:

(a). Score same as three surrounding like signs.

(b). Prior to first recorded score (1) score plus if first two recorded scores are plus, (2) score minus if first recorded score is minus, (3) score plus and minus if first recorded score is plus followed by minus. *Except* that if a shift in range is caused by change in mental age (1) score plus in lower range, (2) score plus and minus in middle range, (3) score minus in upper range.

(c). If score is surrounded by unlike signs, (1) score plus if at least 75 per cent are plus, (2) score plus and minus if 25 to 74 per cent are plus, (3) score minus if less than 25 per cent are plus, *provided* test is recorded in 50 per cent of examinations.

Rule 6. In isolated tests (recorded in less than half examinations):

(a). Score plus if all recorded scores are plus.

(b). Score minus if all recorded scores are minus.

(c). If recorded scores are plus and minus ignore recorded score and score test throughout series (1) minus in upper range, (2) plus and minus in middle range, (3) plus in lower range, *unless,*

(d). If mental age increases, score minus prior to first recorded score, or score according to parts a, b and c of Rule 5 after first recorded score.

Rule 7. Range. Score minus in upper range, plus and minus in middle range and plus in lower range when other rules fail to provide score.

Treatment of original material.—The original records, that is the series of successive examinations for each subject, were carefully checked over for completeness in range of testing. Completeness in range of testing for each examination was effected by supplying scores for unscored tests in accordance with the above objective rules. The mental age for each examination was then calculated by adding to the lowest year where all tests were passed one year for each additional five tests passed. The corresponding life age of each subject was then calculated for each examination.

As was to have been expected from the conditions under which the data were obtained, the time-interval between examinations

was not constant. In order to avoid the difficulty of treating the material with a variable time-interval it seemed desirable to standardize the time element. To accomplish this would very greatly reduce the labor of calculating the data, would simplify the interpretation of results and would make possible a presentation of the essential facts in small compass. The impossibility of presenting tabulations of the 1800 individual mental ages which form the basis of the study is readily comprehended.

Minor variations in successive mental ages also suggested the inadvisability of plotting growth curves based on single mental age determinations. There is an experimental error in every single measurement of mental age.[7] This is a complex result of unavoidable variability in experimental conditions such as time of day, attitude of the subject, attitude and personality of the examiner, technical expertness of the examiner, and so on. In a succession of examinations this error gives mental ages which are sometimes slightly too high and sometimes slightly too low. If one takes the average of two or more mental ages there is a tendency for these experimental errors to offset each other. When the time-interval between examinations is sometimes long and sometimes short one is unable to discover whether a mental age change is really significant or whether it is a chance variation.

In order to standardize the time-interval between examinations and at the same time minimize these minor yet sometimes misleading fluctuations in mental ages it seemed best to 'smooth' the growth records.[8] Experimental statistical treatment of typical

[7] This "error" is more annoying or confusing than serious. In our 1800 examinations the greatest variability between any two successive examinations, however close together, is never greater than 1 year of mental age. The typical variability is about 2 tests, or .4 years, plus or minus. The influence of practice or experience in the successive examinations is practically negligible even when the examinations are frequently repeated at close intervals, except for a slight spurt in the early mental ages of young "improving" subjects. This fact is so obvious from inspection of the detailed records that we have felt justified in omitting the statistical data.

[8] It need hardly be stated that this smoothing process is a legitimate statistical device frequently employed to clarify the interpretation of material of this nature.

cases indicated that the best smoothing was to be obtained by calculating two-year averages of the successive mental ages. It has been noted that some subjects were examined several times in a single year. In other cases the time-interval was sometimes greater than a year (*cf.* Table 1). It was therefore undesirable to use a one-year average, since this would sometimes be based on several tests, sometimes on one test and sometimes would be lacking. A three-year average, on the other hand, effected too much smoothing and tended to obscure fluctuations in mental age which might be significant. But by averaging all the mental ages within a period of two years no significant variation in mental age was obscured and at the same time at least two mental ages were averaged. This procedure had the additional merit of furnishing age intervals of a single year, which furnishes a convenient basis for further calculations.

To effect these averages all mental ages between the beginning of one year and the end of the next year inclusive (from 8.0 to 9.9 for example) were added together and the sum divided by the number of examinations for the period. This average was then employed as the 'true' mental age for the mid-point of the life age period (9.0 in the above example). Hence every mental age was used twice in obtaining the 'true' mental ages. For example, a detailed record of one case shows the following typical succession of observed mental ages:

$$\frac{\text{Mental Age}}{\text{Life Age}} = \frac{7.0}{8.8}; \frac{6.4}{9.3}; \frac{7.2}{9.4}; \frac{7.2}{9.9}; \frac{7.4}{10.5}; \frac{6.8}{10.6}; \frac{7.6}{10.8};$$

$$\frac{7.6}{11.0}; \frac{7.6}{11.3}; \frac{7.8}{12.0}; \frac{7.6}{12.4}; \frac{8.4}{13.3}; \frac{8.2}{13.4}; \frac{8.2}{13.9}; \text{ etc.}$$

The 'true' mental ages, obtained by averaging from the beginning of each year to the end of the next year are (approximating nearest decimal):

$$\frac{\text{Mental Age}}{\text{Life Age}} = \frac{7.0}{9.0}; \frac{7.0}{10.0}; \frac{7.1}{11.0}; \frac{7.4}{12.0}; \frac{7.7}{13.0}; \text{ etc.}$$

Here it will be seen that the second series shows an orderly increase in mental age which is slight but constant in trend, a tendency which is obscured in the variability of the first series.

In those subjects where there was a gap of one year or two years between recorded mental ages the method employed consisted in supplying an hypothetical mental age by means of the average from the mental ages immediately preceding and following the gap. This hypothetical mental age was then used as if it were an observed mental age and an average obtained from its use as in the preceding description. For example, a record shows the following ages (taking only a section of the record):

$$\frac{\text{Mental Age}}{\text{Life Age}} = \frac{7.8}{21.6}; \frac{8.2}{22.0}; \frac{7.8}{25.7}; \frac{7.8}{25.9}; \text{ etc.}$$

The age-gaps to be supplied here are for ages 23 and 24 and are obtained by averaging the mental age (8.2) at age 22 with the mental age (7.8) at age 25. This gives hypothetical mental ages of 7.9 for ages 23 and 24. These are then averaged as if they were observed mental ages, giving the series (approximating to nearest decimal):

$$\frac{\text{Mental Age}}{\text{Life Age}} = \frac{8.0}{22.0}; \frac{8.1}{23.0}; \frac{7.9}{24.0}; \frac{7.8}{25.0}; \text{ etc.}$$

It should be noted that 30 of the 37 subjects where gaps of 2 years were supplied were over 15 years of age, and that the other 7 subjects were all below mental age 7. They are consequently (as will be shown) subjects whose mental levels were not changing except for slight fluctuations plus or minus. Hence the error of supplying these intermediate mental ages is not great.

No attempt was made to calculate the exact average life age on which the average mental ages were calculated. This entails a certain slight error in the tabulations to be presented and introduces a slight error into subsequent calculations. On the average, however, there is no error and the error even at its worst cannot exceed a half year of age. For all practical purposes this slight error is negligible and its harmless presence is more than justified by the facility with which the data may be presented if it is ignored.

Having adopted this method of averaging mental ages we are obliged to discard from our final tabulations the single men-

tal ages of the first year and the last year for each subject. The first year's mental age or the average of the first year's mental ages would be based on fewer measurements than for the other ages, and would be based on a shorter period. Moreover, the time-interval from the first year's measurements to the first 'true' mental age would be a half-year as compared with the whole-year interval at other points. And similarly for the last year's mental ages. Therefore, in order to avoid the error of employing single mental ages at the first and last year (while averages would be used in between) and to avoid the use of half-year intervals the measurements of the first year and the last year of the total period covered are not represented in the final tabulations, except as they influence the first and the last 'true' mental ages which constitute the final basis of the investigation.

Tabulation of data.—The tabulation of data is restricted to the average mental ages (obtained as described above) of 203 subjects at average intervals of one year. For every subject these averaged mental ages cover a period of at least 3 years, representing at least five annual examinations.

The initial ages of the subjects range from 6 years to 66 years. Their mental ages range from 1 year to 10 years. The subjects include both sexes, but no attempt has been made to study sex differences. The proportion of males to females is about 3 to 1.

Classification of the data and subsequent statistical treatment is rendered exceedingly difficult by the nature of the experimental problem. In a preceding discussion we have presented the considerations which led to the formulation of the problem. Briefly restated the problem is to determine: (1) the relation between the age of arrest and final mental age level; and (2) the relation between rate of mental age increase and final mental age level.

The adequate solution of these two problems is very seriously complicated by the wide range in the ages of our subjects. Yet this wide range is needed in order (1) to cover a sufficiently extended life period, and (2) to determine whether increased age brings about a mental age *decrease,* or loss of intelligence, late in

life. The problem is further complicated by the relatively small number of cases which have been examined for long periods of time.

The most satisfactory classification of the data is one based on the *final mental age,* or the terminal intelligence level of the subjects. It is possible from the data to determine this terminal level with a very fair degree of certainty. Displacement of an individual subject in this classification is seldom greater than a half year even when allowance is not made for minor fluctuations in the exact final mental age. This principle of classification has been adopted for the following reasons:

1. It is not possible to classify by the initial mental ages. The subjects are feeble-minded persons who have been sent to an institution not because of a particular age or mental age but because they were believed to be feeble-minded or potentially feeble minded. They have been accepted at the institution on the basis of clinical diagnosis which confirmed that belief. Hence the exact mental ages at the time of first examination are mere accidents. They represent merely the intelligence of the patients when they *happened* to come under observation. In some cases the mental retardation has been very great (in the case of the older subjects), in others it has been slight, and in a few others (the potentially feeble-minded) it has been practically zero. This makes it impracticable to classify subjects on the basis of initial mentality. Moreover, as we shall show later, this classification does not lend itself to an adequate analysis of our problem as formulated.

2. It also seemed desirable to classify the subjects according to life ages at the first examination. This would have made possible a measure of progress at each life age. But this classification was made impossible by the small numbers of subjects and the unequal numbers of subjects at each age, and by the variations in mental ages at each life age. This latter factor introduced an influence of unequal weighting that was undesirable.

3. If we could have eliminated one of the two factors of age and mental age by means of some intelligence ratio our problem would have been relatively simple. The intelligence quotient (I. Q.) is frequently used for this purpose. But the use of the

I. Q. involves two preliminary assumptions, namely, (1) that the level of arrest is independent of the age of arrest (the level being reached at about 16 years of age), and (2) that the rate of development is a constant for all types as well as all degrees of intelligence deviation (idiots excepted). Unless we were willing to make these assumptions we could not use the I. Q. as a basis of classification in this study. An I. Q. of 50, for example based on the ratio $\frac{\text{Mental Age}}{\text{Life Age}} = \frac{4}{8}$, would not be the same as its equivalent ratio of $\frac{\text{Mental Age}}{\text{Life Age}} = \frac{8}{16}$. Moreover, variations in I. Q. are obscured by the fact that increases or losses in mental age must be spread over the entire earlier ages of the subjects instead of simply the time-interval between examinations.

We cannot accept these two assumptions of the I. Q. in this study, for it is these assumptions themselves which form the basis of our investigation. In fact our data will disprove both of these assumptions as applied to feeble-minded subjects.

4. For the same reasons we cannot employ years of retardation as a basis of classification. An increase in years of retardation after the age of arrest is a mere accident of the length of time which has elapsed since that date. Hence if age of arrest is dependent upon level of arrest we cannot employ years of retardation for present purposes.

5. We have made an earnest endeavor to devise an intelligence ratio which would be unaffected by assumptions such as those which invalidate the I. Q. but have been obliged to confess inability to devise such a ratio. The problem seems insoluble in view of the known facts.

6. The classification based on the final mental levels of the subjects is unobjectionable and it exactly serves the purposes of our investigation.

To effect such a classification it is necessary to establish a succession of mental ages which do not materially increase or decrease except for slight fluctuations above and below a final level. Having determined this level the second problem is to determine at what age this level was first reached. The third

problem is to determine the annual mental age increments by which the level was reached. The degree of success with which it is possible to determine the final mental level may be judged from the tabulations of averaged mental ages, for we present the material in full (*cf.* Table 2) in such form that anyone may plot the actual curves of growth.[9]

Our method has been to draw the individual growth curves of each subject and then by inspection to determine the point at which each curve reaches an approximate level. But this may be done almost as readily by inspection of Table 2. It will be seen that with only a few exceptions the mental level is easily determined by inspection. Only 19 per cent of all cases show a net increase in mental age of as much as 1.0 year or more within a period 3 to 5 years. In all but one instance these are subjects who are below 15 years at the initial life age. They represent 38 per cent of all subjects under that age. Only 6 subjects, or 3 per cent, have gained as much as 2 years of mental age in 4 years of life age, that is after 5 annual examinations. *In other words, 97 per cent of all subjects have mental levels which have increased by less than 2 years after 5 annual examinations.*

In classifying the subjects in final mental age groups we have chosen the mental age year-interval within which the majority of fluctuations in level fall. The limits of a group include from the beginning of a mental year to the end of that year, for example 5.0 to 5.9 inclusive. An occasional subject might be displaced by a small fraction of a year above or below classification limit. He will never be displaced by as much as a half year.

Cumulative mental age increases.—The experimental material is presented in Table 2. This table is designed to show the total amounts of increase in mental age for each subject after 1 year, 2 years, and so on of re-examining. The subjects are classified according to final mental age levels and are arranged in order of life ages within each mental age group.

[9] It is not possible to publish the complete data of the 1800 individual mental ages except in this fashion. The original material of the investigation may be obtained from The Training School at Vineland, N. J., for limited periods of time by responsible students who may desire to examine critically the method of treatment here employed.

TABLE 2*

Increases of mental age in repeated Binet tests; 203 feeble-minded subjects classified by final mental age level.

Subject No.	First life age	First mental age	Cumulative mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
Section A—Final mental age 1 year										
1	10	1.7	0	.2	.3	.2	.1			
2	12	1.3	.1	.2	.3					
3	13	1.0	0	0	0	0	0	0		
4	13	1.7	.2	.3	.3	.3	.2	.1		
5	14	1.4	—.4	—.2	.1					
6	19	1.0	0	.1	.3	.3	.3	.3		
Section B—Final mental age 2 years										
7	8	3.1	.7	.6	.2	—.2	—.5			
8	8	2.7	.2	.4	0	—.2	—.1	.3		
9	8	2.0	0	0	0	0				
10	9	1.8	.1	.3	.4	.3	0			
11	11	2.8	.2	.1	—.1	0	.1			
12	11	2.2	.2	.2	.2	.2				
13	13	2.0	0	0	—.1					
14	23	2.4	0	0	0	0	—.1			
Section C—Final mental age 3 years										
15	6	2.6	—.1	.3	.7					
16	7	3.6	0	.4	.2					
17	9	3.4	0	.1	.1	.1	.1			
18	11	4.3	.2	.1	0	—.6	—.7			
19	12	3.0	.2	.6	.4	.4	.3			
20	15	2.8	0	—.1	0	.3	.6			
21	15	3.2	—.2	—.3	—.2	0				
22	16	3.8	0	—.1	—.2	0	—.1			
23	20	3.5	.1	.3	.3	.2	.1	—.1	—.1	
24	25	3.8	.6	.3	—.4	—.4	—.3	—.2		
25	29	3.5	.1	.1	0	—.1	—.2	—.3		
26	32	3.8	.5	.5	.4	—.1	—.3	—.2		
27	34	2.9	.3	.5	.3	.2	.2	.2		
Section D—Final mental age 4 years										
28	8	3.3	.9	1.1	1.1	1.0	1.2	1.5		
29	11	3.6	.3	.4	.2	.2	.4	.6	.9	
30	11	4.3	.2	0	.1					
31	12	3.9	.1	.4	.3	.2	.1	—.1		
32	12	4.4	0	—.2	—.5					
33	12	4.7	.1	—.1	.2	.2				
34	14	3.8	.3	.4	0					
35	14	3.9	.4	.3	0	.1	.4	.5	.3	
36	15	4.5	.2	.1	.1					
37	16	3.9	.5	.6	.4	.3	.2			
38	17	4.3	.1	.3	.2	—.1	.2	.3		
39	21	4.0	.2	.4	.3	.4	.5	.3		
40	22	4.7	0	.1	—.3					
41	22	4.6	.7	1.0	.6	.3	.2	.1		
42	37	4.5	0	0	—.1	—.1	—.1			
43	45	4.6	—.2	—.1	0					

* For explanation of table see p. 52.

TABLE 2 (continued)

Subject No.	First life age	First mental age	Cumulative mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
Section E—Final mental age 5 years.										
44	7	3.7	.1	.2	.4	1.2	1.7	1.9	2.0	2.0
45	9	3.6	1.0	1.6	2.3	2.3				
46	12	4.3	.2	.4	.5	.7	.9	1.3		
47	12	4.5	.2	.3	.5	.6	.7			
48	12	5.6	.2	.3	.3	.3	.3			
49	13	5.1	0	—.1	—.2	—.1				
50	16	4.9	.6	.8	.8	.8	.9			
51	16	4.9	.4	.6	.3	.3	.4	.4		
52	16	5.5	.2	.2	0	0	0	.1		
53	17	4.9	.1	.2	.2	.2	.2			
54	18	4.9	.4	.5	.3	.3	.3			
55	19	5.3	.2	.8	.8	.5				
56	26	5.2	.2	.3	.3	.2	.1			
57	29	4.8	.3	.4	.2	.2	.5	.4	.1	.2
58	30	6.5	—.4	.1	—.8	—1.0				
59	36	5.9	0	—.1	—.5	—.8	—1.0	—1.1		
60	66	5.9	.3	.2	—.2	—.3	—.4			
Section F—Final mental age 6 years										
61	8	3.8	.4	1.3	1.7	2.1	2.3	2.4		
62	8	4.0	.3	1.1	1.3	1.5	1.8	2.0	2.2	
63	9	4.5	.8	1.5	1.6	1.2	1.5	1.6	1.7	
64	10	6.2	.1	.2	.4	.5	.7			
65	11	5.9	.4	.4	.4	.1				
66	11	6.4	.5	.7	.7	.8	.6	.4	.5	.5
67	12	5.1	.9	1.4	1.3	1.6				
68	13	5.2	.6	.7	.5	.7	.8	.9	1.0	
69	15	6.3	.2	.3	.6	.6	.6	.5	.4	.5
70	15	6.4	.3	.4	.4	.4	.4	.3	0	
71	15	6.4	.1	.1	.1	0	0			
72	15	6.7	—.1	—.2	—.2	0				
73	16	6.1	0	—.1	0	.3	.3	.2	.1	0
74	17	6.1	.2	.4	0	—.1	—.2			
75	20	6.4	.3	.4	0	—.1	.2	.3	.1	—.1
76	22	6.0	.2	.4	.3	.2	.1			
77	23	6.8	.3	.2	.2	.1	—.1	—.2	—.2	—.1
78	26	6.3	.3	.2	.2	.3	.4	.5	.3	
79	26	6.6	—.1	0	—.1	—.4	—.2	—.1	—.3	—.1
80	29	6.7	—.2	—.2	0	.1	.1	—.1		
81	30	6.4	.1	.3	.2					
82	32	6.0	.1	.3	.4	.4	.1	.1	.3	
83	32	6.5	—.2	—.1	—.1	—.1	—.1			
84	35	5.9	.3	.4	.5	.5	.5	.4		
85	37	6.3	.7	.7	.2	0	0	.1	0	
Section G—Final mental age 7 years										
86	7	4.9	1.1	1.5	2.0	2.0	2.0	2.4		
87	7	5.6	.4	.7	1.1	1.2	1.4	1.7		
88	7	5.7	1.1	1.4	1.8	1.9	1.8			
89	7	5.7	.8	1.1	1.3	1.7	1.8			
90	8	4.4	1.1	1.8	2.2	3.1	3.1	3.2		
91	8	4.5	1.0	1.5	2.2	2.4	2.5	2.5	2.6	2.8

TABLE 2 (continued)

Section G—Final mental age 7 years (continued)

Subject No.	First life age	First mental age	Cumulative mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
92	8	5.5	.2	.8	1.1	1.6	2.0			
93	8	5.9	.8	1.2	1.1	1.3	1.4			
94	8	6.3	.5	.8	1.2	1.4	1.2	1.4		
95	9	4.3	.7	1.5	2.4	2.8	3.0	3.0	3.0	2.8
96	9	6.6	0	.1	.1	.3	.8	1.0		
97	9	6.7	.6	.7	.6	1.0	1.2			
98	10	7.0	.1	.2	.3	.5	.5	.3	.3	
99	10	7.3	—.2	—.2	.1					
100	11	5.9	.6	.7	1.3	1.6	1.6			
101	11	7.0	.1	.1	.1	.1	.1	.1		
102	11	7.2	.1	.5	.7	.5	.4			
103	12	6.9	.6	.7	.7					
104	13	6.0	.7	1.1	1.1	1.1	1.1	1.1	1.0	.9
105	13	6.4	.5	.4	.4	1.2	1.3			
106	13	6.5	.2	.4	.5	.5	.5			
107	13	6.6	.3	.5	.7	.7	.2	.1		
108	13	7.3	.2	.1	.5	.6				
109	13	7.8	.5	.5	.5	.3	.2	0	0	
110	14	6.9	.4	.5	.7					
111	14	6.7	.5	.4	.4	.5	.5			
112	14	7.5	0	0	0	0				
113	15	7.2	0	.2	.3	.5				
114	16	7.1	0	0	0	—.2	.2	.5	.4	.4
115	17	7.7	0	—.1	.1	0	—.1			
116	19	6.7	.3	.5	.5	.4	.4	.4		
117	19	7.5	.3	.2	.1	.1	0	—.1		
118	20	7.4	.1	.2	.2	.2	.2			
119	20	7.5	.1	.4	.4	.3	.1	.2	.3	
120	20	7.6	.3	.4	.5	.3	.2	.1	0	
121	20	7.7	.2	.5	.4	.3	.2	.2	.1	
122	22	7.8	.5	.5	.1	—.1	—.2	—.1	.3	
123	26	7.8	.2	.2	.1	.1	.2			
124	28	7.5	.2	—.1	—.1	.1	.1			
125	28	7.7	.2	.3	0	—.1	—.2			
126	30	7.6	0	.5	.8	.5	.3	—.2		
127	31	8.4	—.2	—.2	—.3	—.5	—.6	—.6		
128	34	7.7	—.1	—.2	0	.2	0	—.2	—.1	
129	36	7.6	—.4	—.4	—.3	—.3	—.2	—.3	—.5	
130	36	7.2	—.1	0	0	0				
131	38	7.0	.1	.2	.1	.1	.2	.2		
			Section H—Final mental age 8 years							
132	8	6.6	.6	1.0	1.3	1.4				
133	8	7.0	.2	.4	.6	.7	1.1	1.5		
134	8	7.3	.8	.9	.9	.7	.8	.9	.9	
135	9	7.0	.1	.4	.7	1.0	1.2	.9	1.2	1.4
136	9	7.2	.3	.5	.7	.8				
137	10	7.1	.5	.7	1.0	1.2	1.5	1.6	1.4	
138	10	7.6	.8	.9	1.0	1.0	1.2			
139	10	7.8	.6	.7	.7	.9				
140	13	7.9	.2	.2	.2	.6	.5	.7		
141	14	8.0	0	.1	.2	.3	0			

TABLE 2 (continued)

Section H—Final mental age 8 years (continued)

Subject No.	First life age	First mental age	Cumulative mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
142	14	8.1	0	.2	.2					
143	14	8.2	.2	.1	—.3	—.2	0	0		
144	14	8.5	0	—.2	—.2	—.1				
145	15	8.5	.2	.3	.1	.1	.2	.3	.5	
146	15	7.7	0	.2	.4	.3	.3	.3		
147	16	8.1	.1	.2	.2	.2	.2	.7		
148	18	7.8	0	.3	.4	.6	.5	.4	.5	
149	18	8.9	.3	.2	—.3	—.6	—.8	—.7	—.4	
150	21	8.0	.3	.6	.2	0	0	0	—.1	
151	22	8.6	.3	.2	—.2	—.3	—.3	—.1		
152	22	8.6	—.3	—.3	—.1	—.3				
153	23	8.0	.1	.3	.4					
154	23	8.6	.1	0	—.1	—.5	—.6	0		
155	27	8.0	0	.2	.2	.1	0			
156	32	8.5	—.2	—.3	.4	.2	.5			
157	35	8.2	.5	.4	.1	.1	.1	—.5		
158	39	7.8	.2	.6	.7	.9	.7	.6	.4	.4
			Section I—Final mental age 9 years							
159	8	7.6	.2	.4	1.0	1.6				
160	9	7.0	.5	.6	1.0	1.3	1.9	2.1	2.2	
161	9	7.1	.3	.6	.9	1.1	1.9			
162	9	8.2	.3	.8	1.1					
163	9	8.4	.5	.8	.7					
164	10	9.3	.2	.6	.5					
165	11	9.1	.1	.1	.6	.7	.3			
166	12	8.4	.1	.3	.8	1.0	1.3			
167	13	7.5	.5	1.1	1.4	1.4	1.6			
168	13	8.6	.1	.7	1.0	1.2				
169	13	8.9	.4	.6	.9	.9				
170	14	8.4	.4	.9	1.1					
171	14	8.4	.3	.9	1.2	1.0	.8			
172	15	8.6	.1	.1	.2	.3	.5	.7		
173	17	9.1	—.2	.3	.7					
174	17	9.3	.2	—.3	—.3					
175	18	9.5	—.2	.4	—.3	—.3				
176	19	9.0	0	0	.2					
177	21	8.8	.1	.2	.4	.4	.4			
178	23	8.9	.4	.2	.3	.6	.8			
179	26	9.4	0	—.2	—.2	.1	0	—.2		
180	28	9.1	.3	.9	.8					
181	30	9.0	.2	.2	.4	.4	.3			
182	30	9.6	0	.2	.5	.5	.2			
183	33	9.4	.1	.2	.3	.4	.5			
184	40	9.3	.1	.1	.1	.2	.4			
			Section J—Final mental age 10 years							
185	11	8.0	.4	.8	1.3	1.6	2.0			
186	11	8.5	.4	.7	1.5					
187	14	10.4	0	.2	.3	.4				
188	16	9.3	.2	.6	.2	0	.9	1.0	.8	1.1
189	16	9.9	.5	.5	.8	.9	.5	.5	.8	

TABLE 2 (continued)

Section J—Final mental age 10 years (continued)

Subject No.	First life age	First mental age	Cumulative mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
190	16	10.5	—.4	—.3	—.1					
191	16	10.7	.2	.4	.5	.1	.1			
192	17	10.8	.1	.4	.5	.2				
193	18	9.8	.3	.2	.1	.3	.4			
194	19	9.4	.4	1.1	1.4	1.4	1.6	1.1	.9	
195	20	9.9	.2	.5	.3	.4	.7			
196	22	10.0	.1	.1	.1	0	—.1	.3		
197	22	10.7	—.3	—.3	—.2	—.1	—.1			
198	24	10.2	0	.2	.2	.2	.1			
199	24	10.2	.3	.1	.1	.3	.6	.7	.5	
200	25	10.6	0	.2	.5					
201	28	9.8	.4	.6	.6	.6	.5			
202	44	10.5	—.2	—.2	.3					
203	46	9.6	.3	.6	.8	.7	.7			

The first column of this table gives the serial number of the subject. (These are for convenience of reference only and have no other significance.) The second column shows the first average life age of each subject. (This is actually the second year of the original data since the first year has been lost by the method of averaging the data.) The third column shows the first average mental age of each subject. (This is actually the average of all records for the first and second years of the original measurements.) The succeeding columns from left to right show the annual cumulative increases in mental age after the first mental age. (These are obtained by adding the increase at each year to the net total increase of the preceding years.) The first line of the table reads as follows: subject No. 1 with final mental age 1 year, first life age 10 years, first mental age 1.7 years, after 1 year had gained .0 years in mental age, after 2 years had gained .2 years, after 3 years had gained .3 years, etc. The mental ages at each succeeding year may be obtained by adding the cumulative increases to the first mental ages. The life ages increase regularly by 1-year intervals. Thus the first subject just cited would have the following mental ages and life ages:

$$\frac{\text{Mental Age}}{\text{Life Age}} = \frac{1.7}{10.0}; \frac{1.7}{11.0}; \frac{1.9}{12.0}; \frac{2.0}{13.0}; \frac{1.9}{14.0}; \frac{1.8}{15.0}$$

Rate of mental age increase.—The amounts of annual mental age increments may be obtained by subtracting each cumulative increase from the next succeeding (right-hand) cumulative increase. For example, subject No. 1 gained in the first year .0, in the second year .2, in the third .1, in the fourth —.1, and in the fifth —.1.

The annual mental age increments may be expressed as an annual rate of increase by dividing the mental age increment by the life age increment. This may be converted to a percentage

rate of increase by multiplying by 100. This percentage rate of increase must not be confused with or interpreted as a percentage of the total mental age. *It is a percentage of the average normal annual rate of increase* by a scale which is so devised as to provide for a normal average increase of 1 year in mental age for each increase of 1 year in life age up to a given limit of the scale or of age.

These annual rates of increase as percentages of the average normal annual rate can readily be calculated from Table 2. But for convenience in presenting the argument on rate of increase for the feeble-minded, Table 3 is presented to show these rates of increase. The succession of cases and the organization of the material is the same as that of Table 2.

Results.—The best analysis of results is obtained from direct inspection of Table 2 and Table 3. Statistical devices such as expressions of central tendency, coefficients of variability, and coefficients of correlation obscure rather than clarify these results. We believe that by casting the data in the form of the above tables we have achieved a presentation that is much more adequate for purposes of exact analysis than is yielded by the usual statistical methods. We shall be able by inspection to discover trends and variations and at the same time to keep clearly in mind the essential characteristics of each mental age period, of each life age period, and of each individual subject. We shall attempt to formulate certain generalizations on this basis.

Relation of age of arrest to level of arrest.—The analysis of the relation of age of arrest to level of arrest is seriously limited by the lack of sufficient numbers of subjects in the younger age periods. This lack obscures the relationship which may exist. Nevertheless certain trends may be observed as follows:

1. Substantial increases are limited to subjects who are under 15 years of age. Only one subject of this investigation (No. 188) shows as much as one year of permanent increase in mental age after the age of 14 years.

2. Only two subjects show decrease in mental age amounting to as much as one year. One of these is 30 years old and the other 36 at the first record. Twenty-five other subjects who are 30 years or older do not decrease.

TABLE 3

Annual rates of mental age increase in repeated Binet tests: 203 feeble-minded subjects classified by final mental age level.

Subject No.	First life age	First mental age	Successive rates of mental age increase: 1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
Section A—Final mental age 1 year										
1	10	1.7	0	20	10	—10	—10			
2	12	1.3	10	10	10					
3	13	1.0	0	0	0	0	0	0		
4	13	1.7	20	10	0	0	—10	—10		
5	14	1.4	—40	20	30					
6	19	1.0	0	10	20	0	0	0		
Section B—Final mental age 2 years										
7	8	3.1	70	—10	—40	—40	—30			
8	8	2.7	20	20	—40	—20	10	40		
9	8	2.0	0	0	0	0				
10	9	1.8	10	20	10	—10	—30			
11	11	2.8	20	—10	—20	10	10			
12	11	2.2	20	0	0	0				
13	13	2.0	0	0	—10					
14	23	2.4	0	0	0	0	—10			
Section C—Final mental age 3 years										
15	6	2.6	—10	40	40					
16	7	3.6	0	40	—20					
17	9	3.4	0	10	0	0	0			
18	11	4.3	20	—10	—10	—60	—10			
19	12	3.0	20	40	—20	0	—10			
20	15	2.8	0	—10	10	30	30			
21	15	3.2	—20	—10	10	20				
22	16	3.8	0	—10	—10	20	—10			
23	20	3.5	10	20	0	—10	—10	—20	0	
24	25	3.8	60	—30	—70	0	10	10		
25	29	3.5	10	0	—10	—10	—10	—10		
26	32	3.8	50	0	—10	—50	—20	10		
27	34	2.9	30	20	—20	—10	0	0		
Section D—Final mental age 4 years										
28	8	3.3	90	20	0	—10	20	30		
29	11	3.6	30	10	—20	0	20	20	30	
30	11	4.3	20	—20	10					
31	12	3.9	10	30	—10	—10	—10	—20		
32	12	4.4	0	—20	—30					
33	12	4.7	10	—20	30	0				
34	14	3.8	30	10	—40					
35	14	3.9	40	—10	—30	10	30	10	—20	
36	15	4.5	20	—10	0					
37	16	3.9	50	10	—20	—10	—10			
38	17	4.3	10	20	—10	—30	30	10		
39	21	4.0	20	20	—10	10	10	—20		
40	22	4.7	0	10	—40					
41	22	4.6	70	30	—40	—30	—10	—10		
42	37	4.5	0	0	—10	0	0			
43	45	4.6	—20	10	10					

TABLE 3 (continued)

Subject No.	First life age	First mental age	Successive rates of mental age increase: 1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
Section E—Final mental age 5 years										
44	7	3.7	10	10	20	80	50	20	10	0
45	9	3.6	100	60	70	0				
46	12	4.3	20	20	10	20	20	40		
47	12	4.5	20	10	20	10	10			
48	12	5.6	20	10	0	0	0			
49	13	5.1	0	—10	—10	10				
50	16	4.9	60	20	0	0	10			
51	16	4.9	40	20	—30	0	10	0		
52	16	5.5	20	0	—20	0	0	10		
53	17	4.9	10	10	0	0	0			
54	18	4.9	40	10	—20	0	0			
55	19	5.3	20	60	0	—30				
56	26	5.2	20	10	0	—10	—10			
57	29	4.8	30	10	—20	0	30	—10	—30	10
58	30	6.5	—40	50	—90	—20				
59	36	5.9	0	—10	—40	—30	—20	—10		
60	66	5.9	30	—10	—40	—10	—10			
Section F—Final mental age 6 years										
61	8	3.8	40	90	40	40	20	10		
62	8	4.0	30	80	20	20	30	20	20	
63	9	4.5	80	70	10	—40	30	10	10	
64	10	6.2	10	10	20	10	20			
65	11	5.9	40	0	0	—30				
66	11	6.4	50	20	0	10	—20	—20	10	0
67	12	5.1	90	50	—10	30				
68	13	5.2	60	10	—20	20	10	10	10	
69	15	6.3	20	10	30	0	0	—10	—10	10
70	15	6.4	30	10	0	0	0	—10	—30	
71	15	6.4	10	0	0	—10	0			
72	15	6.7	—10	—10	0	20				
73	16	6.1	0	—10	10	30	0	—10	—10	—10
74	17	6.1	20	20	—40	—10	—10			
75	20	6.4	30	10	—40	—10	30	10	—20	—20
76	22	6.0	20	20	—10	—10	—10			
77	23	6.8	30	—10	0	—10	—20	—10	0	10
78	26	6.3	30	—10	0	10	10	10	—20	
79	26	6.6	—10	10	—10	—30	20	10	—20	20
80	29	6.7	—20	0	20	10	0	—20		
81	30	6.4	10	20	—10					
82	32	6.0	10	20	10	0	—30	0	20	
83	32	6.5	—20	10	0	0	0			
84	35	5.9	30	10	10	0	—10	0		
85	37	6.3	70	0	—50	—20	0	10	—10	
Section G—Final mental age 7 years										
86	7	4.9	110	40	50	0	0	40		
87	7	5.6	40	30	40	10	20	30		
88	7	5.7	110	30	40	10	—10			
89	7	5.7	80	30	20	40	10			
90	8	4.4	110	70	40	90	0	10		
91	8	4.5	100	50	70	20	10	0	10	20

TABLE 3 (continued)

Section G—Final mental age 7 years (continued)

Subject No.	First life age	First mental age	Successive rates of mental age increase 1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
92	8	5.5	20	60	30	50	40			
93	8	5.9	80	40	—10	20	10			
94	8	6.3	50	30	40	20	—20	20		
95	9	4.3	70	80	90	40	20	0	0	—20
96	9	6.6	0	10	0	20	50	20		
97	9	6.7	60	10	—10	40	20			
98	10	7.0	10	10	10	20	0	—20	0	
99	10	7.3	—20	0	30					
100	11	5.9	60	10	60	30	0			
101	11	7.0	10	0	0	0	0	0		
102	11	7.2	10	40	20	—20	—10			
103	12	6.9	60	10	0					
104	13	6.0	70	40	0	0	0	0	—10	—10
105	13	6.4	50	—10	0	80	10			
106	13	6.5	20	20	10	0	0			
107	13	6.6	30	20	20	0	—50	—10		
108	13	7.3	20	—10	40	10				
109	13	7.8	50	0	0	—20	—10	—20	0	
110	14	6.9	40	10	20					
111	14	6.7	50	—10	0	10	0			
112	14	7.5	0	0	0	0				
113	15	7.2	0	20	10	20				
114	16	7.1	0	0	0	—20	40	30	—10	0
115	17	7.7	0	—10	20	—10	—10			
116	19	6.7	30	20	0	—10	0	0		
117	19	7.5	30	—10	—10	0	—10	—10		
118	20	7.4	10	10	0	0	0			
119	20	7.5	10	30	0	—10	—20	10	10	
120	20	7.6	30	10	10	—20	—10	—10	—10	
121	20	7.7	20	30	—10	—10	—10	0	—10	
122	22	7.8	50	0	—40	—20	—10	10	40	
123	26	7.8	20	0	—10	0	10			
124	28	7.5	20	—30	0	20	0			
125	28	7.7	20	10	—30	—10	—10			
126	30	7.6	0	50	30	—30	—20	—50		
127	31	8.4	—20	0	—10	—20	—10	0		
128	34	7.7	—10	—10	20	20	—20	—20	10	
129	36	7.6	—40	0	10	0	10	—10	—20	
130	36	7.2	—10	10	0	0				
131	38	7.0	10	10	—10	0	10	0		
			Section H—Final mental age 8 years							
132	8	6.6	60	40	30	10				
133	8	7.0	20	20	20	10	40	40		
134	8	7.3	80	10	0	—20	10	10	0	
135	9	7.0	10	30	30	30	20	—30	30	20
136	9	7.2	30	20	20	10				
137	10	7.1	50	20	30	20	30	10	—20	
138	10	7.6	80	10	10	0	20			
139	10	7.8	60	10	0	20				
140	13	7.9	20	0	0	40	—10	20		
141	14	8.0	0	10	10	10	—30			

TABLE 3 (continued)

Section H—Final mental age 8 years (continued)

Subject No.	First life age	First mental age	Successive rates of mental age increase: 1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
142	14	8.1	0	20	0					
143	14	8.2	20	—10	—40	10	20	0		
144	14	8.5	0	—20	0	10				
145	15	8.5	20	10	—20	0	10	10	20	
146	15	7.7	0	20	20	—10	0	0		
147	16	8.1	10	10	0	0	0	50		
148	18	7.8	0	30	10	20	—10	—10	10	
149	18	8.9	30	—10	—50	—30	—20	10	30	
150	21	8.0	30	30	—40	—20	0	0	—10	
151	22	8.6	30	—10	—40	—10	0	20		
152	22	8.6	—30	0	20	—20				
153	23	8.0	10	20	10					
154	23	8.6	10	—10	—10	—40	—10	60		
155	27	8.0	0	20	0	—10	—10			
156	32	8.5	—20	—10	70	—20	30			
157	35	8.2	50	—10	—30	0	0	—60		
158	39	7.8	20	40	10	20	—20	—10	—20	0
		Section I—Final mental age 9 years								
159	8	7.6	20	20	60	60				
160	9	7.0	50	10	40	30	60	20	10	
161	9	7.1	30	30	30	20	80			
162	9	8.2	30	50	30					
163	9	8.4	50	30	—10					
164	10	9.3	20	40	—10					
165	11	9.1	10	0	50	10	—40			
166	12	8.4	10	20	50	20	30			
167	13	7.5	50	60	30	0	20			
168	13	8.6	10	60	30	20				
169	13	8.9	40	20	30	0				
170	14	8.4	40	50	20					
171	14	8.4	30	60	30	—20	—20			
172	15	8.6	10	0	10	10	20	20		
173	17	9.1	—20	50	40					
174	17	9.3	20	—50	0					
175	18	9.5	—20	60	—70	0				
176	19	9.0	0	0	20					
177	21	8.8	10	10	20	0	0			
178	23	8.9	40	—20	10	30	20			
179	26	9.4	0	—20	0	30	—10	—20		
180	28	9.1	30	60	—10					
181	30	9.0	20	0	20	0	—10			
182	30	9.6	0	20	30	0	—30			
183	33	9.4	10	10	10	10	10			
184	40	9.3	10	0	0	10	20			
		Section J—Final mental age 10 years								
185	11	8.0	40	40	50	30	40			
186	11	8.5	40	30	80					
187	14	10.4	0	20	10	10				
188	16	9.3	20	40	—40	—20	90	10	—20	30
189	16	9.9	50	0	30	10	—40	0	30	

TABLE 3 (continued)

Section J—Final mental age 10 years (continued)

Subject No.	First life age	First mental age	Successive rates of mental age increase: 1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
190	16	10.5	—40	10	20					
191	16	10.7	20	20	10	—40	0			
192	17	10.8	10	30	10	—30				
193	18	9.8	30	—10	—10	20	10			
194	19	9.4	40	70	30	0	20	—50	—20	
195	20	9.9	20	30	—20	10	30			
196	22	10.0	10	0	0	—10	—10	40		
197	22	10.7	—30	0	10	10	0			
198	24	10.2	0	20	0	0	—10			
199	24	10.2	30	—20	0	20	30	10	—20	
200	25	10.6	0	20	30					
201	28	9.8	40	20	0	0	—10			
202	44	10.5	—20	0	50					
203	46	9.6	30	30	20	—10	0			

3. Only 38 subjects gain as much as at least one year within at least five years. All but one are under 15 years of age at the first record. None of these increases as much as a year after 15 years. Ninety-five subjects are under 15 years of age at the first record; hence only 39 per cent of these subjects who are under 15 at first record show improvement amounting to at least one year in 5 years. That is, 61 per cent of subjects (58 cases) who are under 15 years of age at first record fail to show mental age increases amounting to as much as a single year after in most cases 4 or 5 years.

The distribution of 'gains' and 'no gains' for all subjects under 15 years of age at first record by final mental level is given in Table 4. The last line of Table 4 is a clear indication of the

TABLE 4

Relation of improvability to final mental level among subjects under 15 years of life age.

Final mental age	1	2	3	4	5	6	7	8	9	10	Tot.
Number subjects each mental age	5	7	5	8	6	8	27	13	13	3	95
Number gaining one year or more				1	2	4	14	5	9	2	37
Per cent gaining a year or more	0	0	0	13	33	50	52	39	69	67	39

general dependence of age of arrest upon level of arrest. The percentage of subjects under 15 years of age at first record who increase as much as at least one year in at least 5 years steadily increases from 0 at final mental age 1 year to 67 at final mental age 10 years. Or, conversely, the number of those who fail to

increase becomes steadily less and less from the lower to the higher mental levels. That is to say, *the lower the mental level the greater the number of subjects who have reached their final level.* And since the distribution of first life ages is approximately the same for all the mental levels (see Table 2) it follows that the *lower the mental level the earlier the age of arrest.*

4. It is extremely difficult to fix the actual age of arrest for each mental level from the data in hand, because of the lack of sufficient numbers of young subjects. We have observed that all subjects regardless of specific mental level are arrested before 15 years of age, in the sense that after 14 they do not show as much as one year of mental age increase. We can go further. The ages for each mental level at which all subjects are arrested are as follows:

Mental age level	1	2	3	4	5	6	7	8	9	10
Age of arrest	10	8	6	11	12	15	15	12	15	14

This table is irregular because of inadequate data. All subjects were arrested *at least* by these ages. The majority of the subjects (166 subjects, or 82 per cent) do not improve materially after the first recorded age. Fifty-eight of these are under the age of 15, yet they were fully arrested when first examined. That individual variability is influenced by both age and mental age is obvious from careful inspection of Table 2. The idiots (mental age 1 and 2 years) are all arrested by 10 years of age, but we cannot say how much sooner. At mental age 3 years all subjects are arrested by 6 years of age, but there are only a few young subjects. At mental age 4 there is only one subject under age 11. And so on for the other levels.

5. There is observed among subjects who are older than the age of arrest for their mental level a slight tendency to decrease in successive examinations independently of actual age. This is strong evidence that there is not only no marked influence of coaching but that if the factor of age or experience plays a positive part on some tests it also must play a negative part on others. That is, if some tests are tests of age rather than tests of intelligence, increase of age may bring about more losses than gains. Probably, however, the institution life tends to shear the subjects

of certain superficial appearances of intelligence of the sort which might give a spuriously high mental age at first examinations. That is, the so-called tests of information like naming days of the weeks, giving the date, and the like might be passed on admission but not passed after several years in the institutional environment. But in any case the losses are very slight and so irregular from subject to subject that the question is not a practically serious one.

6. In general the data lead to four general principles, none of which can be stated with statistical exactness because of inadequate data; (a) age of arrest is associated with level of arrest, although the numerical relationship cannot yet be stated (*cf.* however, pp. 73 to 76); (b) within a particular final mental age group the younger subjects are more likely to improve than the older, *independently of actual retardation;* (c) gains are restricted to subjects who are under 15 years of age; and (d) variability is very great and prognosis on the basis of mental age alone practically impossible for individuals. That is, initial mental age gives no definite indication of final mental age. The actual course of mental age growth must be traced out by actual repeated examinations in the case of feeble-minded subjects.

An objection may be raised against the method of analysis on the ground that in using one year of mental age increase as a minimum indication of significant increase we have employed a misleading criterion. A year of difference in mental age does not mean the same thing at different life ages (*cf.* pp. 85 ff.). Moreover, a year of increase at mental age 2 years is an increase of 50 per cent of mental age while at mental age 10 years it is an increase of only 10 per cent. We may meet this objection by certain practical considerations. It is impracticable to recognize increases of less than one year because of what Goddard calls 'the normal variability of the abnormal mind'; unless the increases are consistent in trend they ordinarily represent only minor fluctuations in the mental level. We need not, however, insist upon this point. We shall come to similar but more exact conclusions by a method of analysis which is independent of this criterion and employs instead the actual average mental age increments from age to age for each mental age group.

Rate of development.—The second phase of the problem of feeble-minded growth calls for an examination of the annual rate of growth. The data have already been treated in such a way as to show the annual rates of mental age increase (*cf.*

Table 3) in terms of a percentage of the average normal rate (which by the Binet Scale is standardized at one year of increase in mental age for each year of increase in life age). The analysis of Table 2 and Table 3 has already shown that growth is limited to the subjects who are under 15 years of age. We may therefore confine the study of rate of growth to subjects under 15 years of age.

Most of the subjects under 15 years of age are developing at a very slow rate. We have seen that only 37 of them, or 39 per cent, have gained as much as a year or more after 3 to 5 years of repeated examining. That is, 61 per cent gain less than 1 year in 3 to 5 years or gain at a net average rate which is never greater than 30 per cent of the average normal rate and ordinarily is less than 20 per cent. Even among those who do gain a year this gain frequently requires 5 years of time, which is a net average rate of only 20 per cent.

Rate of growth may be a function of life age, or of mental age, or of degree of retardation. (It is of course affected by physiological conditions due to accident, disease, or hereditary predisposition but in the present discussion we are obliged to ignore these influences.) Our study of individual subjects (*cf.* Tables 2 and 3) has indicated that individual variations in rate are very great. Some subjects make no significant gains even when age, mental age and degree of retardation all suggest expectation of gains. On the other hand some subjects whose mental ages are low, whose life ages are high and whose retardation is very great, suddenly show marked increases in mental growth.

We must therefore resort to a study of averages, and we must study the data without making assumptions which might limit the value of the conclusions. Hence we must study the influences of age and mental age independently before we can study the influence of degree of retardation, which is the relation of mental age to life age. We cannot, therefore, employ such a device as the intelligence quotient, because that device is founded on assumptions whose validity we desire to test. This necessity makes statistical treatment of the data very difficult. A study of

the influence of age gives obscure results because of the unequal distributions of mental age at each life age grouping. Similarly a study of the dependence of rate upon mental age is spuriously affected by unequal distributions of life age at each mental age grouping. The desirable statistical method would be to calculate the coefficients of correlation and then correct for constriction or dilation caused by 'spurious' factors. This method is of doubtful significance because of the striking deviations of individual subjects, the small numbers of subjects in some categories, and the variable factors in the selection of subjects. Moreover, the relationship between rate and life age is non-rectilinear, while the relationship between rate and mental age is rectilinear. But the greatest difficulty is that of selecting a satisfactory basis of classification.

Trial calculations indicate that the rate of growth is practically independent of mental age. There is a slight negative correlation between rate of growth and mental age. But this is due to a negative correlation between rate and life age between 8 and 15 years of age, combined with a slight positive correlation between mental age and life age.

Relation of rate to life age.—We are concerned with the *amounts* of increase as well as the strength of the tendency. Therefore it seemed advisable to calculate the actual average rates of increase for the successive life ages. We could then plot the average functional relation between rate and life age. If there were at any life age a correlation between rate and mental age it would be necessary to allow for this influence. But if the distribution of mental ages at each life age period is approximately the same from age to age, then an average rate of growth by life age may be established independently of mental age. Or if there is no significant correlation between mental age and rate of growth at each life age grouping, then again the rate of growth will appear as a function of life age independently of mental age.

Table 5 is presented to show the annual growth increments by life age. This tabulation covers only the crucial period, namely the ages below 16 years at first record. The data of Table 5

TABLE 5

Relation of annual rate of mental age increase to life age, mental age, and I. Q.

Section A—Life age 7 years
7 subjects

Subject No.	Mental age	I. Q.	Annual rate
15	2.5	36	40
16	3.6	51	0
44	3.7	53	10
86	4.9	70	110
87	5.6	80	40
88	5.7	81	110
89	5.7	81	80
Ave.	4.5	65	56

Section B—Life age 8 years
22 subjects

9	2.0	25	0
8	2.7	34	20
15	2.9	36	40
7	3.1	39	70
28	3.3	41	90
16	3.6	45	40
44	3.8	48	10
61	3.8	48	40
62	4.0	50	30
90	4.4	55	110
91	4.5	56	100
92	5.5	69	20
93	5.9	74	80
86	6.0	75	40
87	6.0	75	30
94	6.3	79	50
89	6.5	81	30
132	6.6	83	60
88	6.8	85	30
133	7.0	88	20
134	7.3	91	80
159	7.6	95	20
Ave.	5.0	62	46

Section C—Life age 9 years
34 subjects

10	1.8	20	10
9	2.0	22	0
8	2.9	32	20
17	3.4	38	0
45	3.6	40	100
7	3.8	42	—10
44	3.9	43	20
16	4.0	44	—20
28	4.2	47	20
61	4.2	47	90
62	4.3	48	80
95	4.3	48	70

Section C—(continued)

Subject No.	Mental age	I. Q.	Annual rate
63	4.5	50	80
90	5.5	61	70
91	5.5	61	50
92	5.7	63	60
87	6.3	70	40
86	6.4	71	50
96	6.6	73	0
93	6.7	74	40
97	6.7	74	60
89	6.8	76	20
94	6.8	76	30
135	7.0	78	10
160	7.0	78	50
88	7.1	79	40
161	7.1	79	30
132	7.2	80	40
133	7.2	80	20
136	7.2	80	30
159	7.8	87	20
134	8.1	90	10
162	8.2	91	30
163	8.4	93	50
Ave.	5.7	63	36

Section D—Life age 10 years
41 subjects

1	1.7	17	0
10	1.9	19	20
9	2.0	20	0
8	3.1	31	—40
17	3.4	34	10
7	3.7	37	—40
44	4.1	41	80
28	4.4	44	0
45	4.6	46	60
95	5.0	50	80
61	5.1	51	40
62	5.1	51	20
63	5.3	53	70
91	6.0	60	70
64	6.2	62	10
90	6.2	62	40
92	6.3	63	30
96	6.6	66	10
87	6.7	67	10
86	6.9	69	0
89	7.0	70	40
98	7.0	70	10
93	7.1	71	—10
94	7.1	71	40

TABLE 5 (continued)

Section D—(continued)

Subject No.	Mental age	I. Q.	Annual rate
135	7.1	71	30
137	7.1	71	50
97	7.3	73	10
99	7.3	73	—20
161	7.4	74	30
133	7.4	74	20
88	7.5	75	10
136	7.5	75	20
160	7.5	75	10
132	7.6	76	30
138	7.6	76	80
139	7.8	78	60
159	8.0	80	60
134	8.2	82	0
162	8.5	85	50
163	8.9	89	30
164	9.3	93	20
Ave.	6.2	62	25

Section E—Life age 11 years
54 subjects

1	1.7	15	20
9	2.0	18	0
10	2.1	19	10
12	2.2	20	20
8	2.7	25	—20
11	2.8	25	20
7	3.3	30	—40
17	3.5	32	0
29	3.6	33	30
18	4.3	39	20
30	4.3	39	20
28	4.4	40	—10
44	4.9	45	50
45	5.2	47	70
62	5.3	48	20
61	5.5	50	40
95	5.8	53	90
65	5.9	54	40
100	5.9	54	60
63	6.0	55	10
64	6.3	57	10
66	6.4	58	50
90	6.6	60	90
92	6.6	60	50
91	6.7	61	20
96	6.7	61	0
87	6.8	62	20
86	6.9	63	0
93	7.0	64	20
101	7.0	64	10
98	7.1	65	10

Section E—(continued)

Subject No.	Mental age	I. Q.	Annual rate
99	7.1	65	0
102	7.2	65	10
89	7.4	67	10
97	7.4	67	—10
135	7.4	67	30
94	7.5	68	20
137	7.6	69	20
88	7.6	69	—10
133	7.6	69	10
160	7.6	69	40
136	7.7	70	20
161	7.7	70	30
132	7.9	72	10
185	8.0	73	40
134	8.2	75	—20
138	8.4	76	10
139	8.4	76	10
186	8.5	77	40
159	8.6	78	60
162	9.0	82	30
165	9.1	83	10
163	9.2	84	—10
164	9.5	86	40
Ave.	6.3	57	21

Section F—Life age 12 years
58 subjects

Subject No.	Mental age	I. Q.	Annual rate
2	1.3	11	10
1	1.9	16	10
10	2.2	18	—10
12	2.4	20	0
8	2.5	21	10
7	2.9	24	—30
11	3.0	25	—10
19	3.0	25	20
17	3.5	29	0
29	3.9	33	10
31	3.9	33	10
28	4.3	36	20
46	4.3	36	20
32	4.4	37	0
18	4.5	38	—10
30	4.5	38	—20
47	4.5	38	20
33	4.7	39	10
67	5.1	43	90
44	5.4	45	20
62	5.5	46	30
48	5.6	47	20
45	5.9	49	0

TABLE 5 (continued)

Section F—(continued)

Subject No.	Mental age	I. Q.	Annual rate
61	5.9	49	20
63	6.1	51	—40
65	6.3	53	0
64	6.4	53	20
100	6.5	54	10
95	6.7	56	40
96	6.7	56	20
66	6.9	58	20
86	6.9	58	40
91	6.9	58	10
103	6.9	58	60
87	7.0	58	30
92	7.1	59	40
101	7.1	59	0
99	7.1	59	30
93	7.2	60	10
98	7.2	60	10
97	7.3	61	40
102	7.3	61	40
90	7.5	63	0
94	7.7	64	—20
133	7.7	64	40
135	7.7	64	30
137	7.8	65	30
137	7.9	66	10
134	8.0	67	10
160	8.0	67	30
161	8.0	67	20
166	8.4	70	10
185	8.4	70	40
138	8.5	71	10
139	8.5	71	0
186	8.9	74	30
165	9.2	77	0
164	9.9	83	—10
Ave.	6.0	50	15

Section G—Life age 13 years
64 subjects

3	1.0	8	0
2	1.4	11	10
4	1.7	13	20
1	2.0	15	—10
13	2.0	15	0
10	2.1	16	—30
12	2.4	18	0
8	2.6	20	40
11	2.9	22	—20
19	3.2	25	40
17	3.5	27	0
29	4.0	31	—20
31	4.0	31	30

Section G—(continued)

Subject No.	Mental age	I. Q.	Annual rate
30	4.3	33	10
18	4.4	34	—10
32	4.4	34	—20
28	4.5	35	30
46	4.5	35	20
47	4.7	36	10
33	4.8	37	—20
49	5.1	39	0
68	5.2	40	60
44	5.6	43	10
63	5.7	44	30
48	5.8	45	10
62	5.8	45	20
67	6.0	46	50
104	6.0	46	70
61	6.1	47	10
65	6.3	48	0
105	6.4	49	50
106	6.5	50	20
64	6.6	51	10
100	6.6	51	60
107	6.6	51	30
96	6.9	53	50
91	7.0	54	0
66	7.1	55	0
95	7.1	55	20
101	7.1	55	0
98	7.3	56	20
108	7.3	56	20
90	7.5	58	10
94	7.5	58	20
103	7.5	58	10
167	7.5	58	50
97	7.7	59	20
102	7.7	59	20
109	7.8	60	50
140	7.9	61	20
135	8.0	62	20
133	8.1	62	40
134	8.1	62	10
137	8.1	62	20
161	8.2	63	80
160	8.3	64	60
139	8.5	65	20
166	8.5	65	20
138	8.6	66	0
168	8.6	66	10
185	8.8	68	50
169	8.9	69	40
165	9.2	71	50
186	9.2	71	80
Ave.	6.0	46	21

TABLE 5 (continued)

Section H—Life age 14 years
63 subjects

Subject No.	Mental age	I. Q.	Annual rate
3	1.0	7	0
5	1.4	10	—40
2	1.5	11	10
1	1.9	14	—10
4	1.9	14	10
13	2.0	14	0
12	2.4	17	0
11	2.7	19	10
19	3.6	26	—20
29	3.8	27	0
34	3.8	27	30
35	3.9	28	40
32	4.2	30	—30
18	4.3	31	—60
31	4.3	31	—10
33	4.6	33	30
46	4.7	34	10
47	4.8	34	20
49	5.1	36	—10
68	5.8	41	10
48	5.9	42	0
62	6.0	43	20
63	6.0	43	10
65	6.3	45	—30
67	6.5	46	—10
64	6.7	48	20
104	6.7	48	40
106	6.7	48	20
111	6.7	48	50
105	6.9	49	—10
107	6.9	49	20
110	6.9	49	40
91	7.0	50	10
66	7.1	51	10
101	7.1	51	0
100	7.2	51	30
95	7.3	52	0
96	7.4	53	20
98	7.5	54	0
108	7.5	54	—10
112	7.5	54	0
103	7.6	54	0
102	7.9	56	—20
141	8.0	57	0
167	8.0	57	60
140	8.1	58	0
142	8.1	58	0
134	8.2	59	0
135	8.2	59	—30
143	8.2	59	20
109	8.3	59	0
137	8.3	59	30

Subject H—(continued)

Subject No.	Mental age	I. Q.	Annual rate
170	8.4	60	40
171	8.4	60	30
144	8.5	61	0
138	8.6	61	20
166	8.7	62	50
168	8.7	62	60
160	8.9	64	20
169	9.3	66	20
185	9.3	66	30
165	9.7	69	10
187	10.4	74	0
Ave.	6.3	45	9

Section I—Life age 15 years
63 subjects

Subject No.	Mental age	I. Q.	Annual rate
3	1.0	7	0
5	1.0	7	20
4	2.0	13	0
13	2.0	13	—10
11	2.8	19	10
20	2.8	19	0
21	3.2	21	—20
19	3.4	23	0
18	3.7	25	—10
29	3.8	25	20
34	4.1	27	10
31	4.2	28	—10
35	4.3	29	—10
36	4.5	30	20
46	4.8	32	20
33	4.9	33	0
47	5.0	33	10
49	5.0	33	—10
48	5.9	39	0
68	5.9	39	—20
63	6.1	41	10
69	6.3	42	20
67	6.4	43	30
70	6.4	43	30
71	6.4	43	10
72	6.7	45	—10
105	6.8	45	0
106	6.9	46	10
91	7.1	47	20
101	7.1	47	0
104	7.1	47	0
107	7.1	47	20
66	7.2	48	—20
111	7.2	48	—10
113	7.2	48	0

TABLE 5 (continued)

Section I—(continued)				Section I—(continued)			
Subject No.	Mental age	I. Q.	Annual rate	Subject No.	Mental age	I. Q.	Annual rate
95	7.3	49	0	145	8.5	57	20
110	7.3	49	10	137	8.6	57	10
108	7.4	49	40	167	8.6	57	30
98	7.5	50	—20	172	8.6	57	10
100	7.5	50	0	171	8.7	58	60
112	7.5	50	0	170	8.8	59	50
102	7.7	51	—10	160	9.1	61	10
146	7.7	51	0	166	9.2	61	20
135	7.9	53	30	168	9.3	62	30
141	8.0	53	10	169	9.5	63	30
140	8.1	54	0	185	9.6	64	40
142	8.1	54	20	165	9.8	65	—40
109	8.3	55	0	187	10.4	69	20
143	8.4	56	—10				
144	8.5	57	—20	Ave.	6.5	44	8

are derived directly from Table 2. The table shows each subject at each of his life ages. In the first column is the identification number of each subject corresponding to his position in Table 2. The mental age at each life age (that is, the initial mental age plus the intervening increment) is given in the second column, then the I. Q., or the predicted rate that would ensue if this ratio (I. Q.) were a constant, then the actual rate of growth for the ensuing year.

It is fairly obvious from this table that there is no consistent dependence of rate of growth upon mental age at any life-age grouping. Each grouping is arranged in order of ascending mental age. But the rate of growth shows no corresponding increase in value. As a general rule there is some tendency for an increase from the low mental ages to the middle mental ages and then a decrease. This is in spite of the fact that the higher mental ages show lesser degrees of retardation. The actual Pearson coefficients of correlation were computed for age-groups 9 years and 11 years as samples. In each case the coefficient was $r = .12$ (P. E. $= .10$ and $.09$ respectively). This is practically no correlation, or only as great as might be expected by chance. The average rates of increase for each age-group (including also some ages above 15) are shown in Table 6.

Tables 5 and 6 show more clearly than was apparent from Table 3 that the average rate of mental age increase is relatively

TABLE 6

Average annual rates of mental age increase by life ages.

Life age	No. of subjects	Average mental age	Average I. Q.	Average annual rate
7	7	4.5	65	56
8	22	5.0	62	46
9	34	5.7	63	36
10	41	6.2	62	25
11	54	6.3	57	21
12	58	6.0	50	15
13	64	6.0	46	21
14	63	6.3	45	9
15	63	6.5	44	8
16	57	6.6	41	7
17	51	6.8	43	5
18	46	7.1	44	3
19	41	7.3	46	7
20	40	7.3	46	4
21	34	7.3	46	9
22	32	7.6	48	6

independent of mental age or degree of retardation. It is instead a function of life age. There is some tendency at each age for the rate to increase with mental age from mental age 1 year to about mental age 5 years or 6 years; after this point the rate tends to decrease. The net result of these compensating tendencies is to produce a negligible correlation between rate and mental age at each life age. Table 6 shows some tendency for the average mental ages of each life age group to increase. This is because more high-grade subjects are included in the higher age-groups. It is generally believed that the high-grade and less retarded subjects have higher rates of development than the low-grade and grossly retarded subjects. We should therefore expect that the entry of high-grade subjects would increase the rate; but as a matter of fact the rate decreases with increase of life age in spite of the entry of the high-grade subjects. Without them it might decrease more rapidly or come to a minimum at an earlier age than is shown in Table 6.

We may conclude from Tables 5 and 6 that *the average rate of mental age increase of these feeble-minded subjects decreases regularly and steadily between the ages of 8 and 14 years and reaches a practical minimum at 13 or 14 years.* This is in spite of the fact that in the higher age groups we have an increasingly greater number of high-grade and less retarded subjects. It is

probably something more than a coincidence that this age of arrest of the average rate of growth coincides with the age of arrest of average normal subjects previously discussed.

This conclusion that the average rate of growth decreases with increase of life age seems to contradict one of our previous conclusions that the age of arrest is a function of the level of arrest. It is therefore desirable to study the data from still another point of view.

Rate of growth of 'improving' subjects.—The treatment of data offered in Table 5 is open to the criticism that a majority of the subjects have a rate of increase which is practically negligible. It has been shown (*cf.* Tables 2 and 3) that 61 per cent of all subjects under 15 years of age at first examinations do not improve as much as a year mentally in 3 to 5 years; for these subjects the rate of increase represents only minor fluctuations plus or minus from a final mental age level. In other words 61 per cent of the subjects represented in Table 5 are not increasing significantly in mental age. The inclusion of these subjects has a tendency to obscure the actual influence of mental age upon rate of increase, that is to say, they contribute negatively to the results summarized in Table 6. Consequently it is desirable to study only the 'improving' subjects who contribute positively to the rate of increase. These cases, who constitute 39 per cent of all subjects under 15 years of age at first examinations, have been gathered together for special study. They have been selected from Table 2 (as indicated by the subject numbers) on the basis of having gained at least a year of mental age in 3 to 5 years of life age. The successive net total mental age increases of these subjects at each year of repeated examination are presented in Table 7, arranged in ascending order of life age at first record.

We might measure the strength of the tendency of rate to be associated with age or mental age by means of correlation coefficients. But as was previously pointed out this would yield only a measure of correlation tendency. Moreover, there are certain spurious influences which cannot fully be allowed for.[10] To

[10] The limitations of the correlation method have been well stated by

make an analysis which shall show the actual amounts of increase in rate with increase in age and at the same time show the influence of mental age and the influence of repeated testing we have sorted out from Table 7 the subjects whose first ages are 7, 8 and 9 years for special study, these ages representing a majority of the subjects of Table 7. Fearing a possible influence of repeated examination, as a result of which the successive increases might show gains due to practice or experience in the tests, we have not combined all subjects at a given age (as was done in Table 5) but have grouped the subjects only according to first life ages. The treatment of these subjects is presented in Table 8. This table shows the successive ages, the mental ages for each age, the I. Q.'s and the rates of growth of those improving subjects whose first life ages were 7, 8 and 9 years. Unfortunately the number of subjects is rather small at each age.

Inspection shows that there is no positive correlation between increase in rate and increase in mental age or I. Q. Indeed there is an observable tendency for a *negative* correlation, that is, a tendency for the lower mental ages or the more retarded subjects to show larger rates of increase than the higher mental

Thurstone (33, p. 3). He says: "A correlation coefficient considerably less than unity may be explained in at least four different ways: (1) the observations may be so inaccurate as to obscure the relationship; (2) the two variables may be related through a common third variable which, if not controlled or kept constant, plays havoc with the experiment; (3) the regression may be non-linear, in which case the Pearson coefficient, r, is almost meaningless; (4) the two variables may be intrinsically independent." It seemed desirable to measure the numerical degree of relationship between rate of growth and mental age by means of the correlation coefficient. But this correlation is affected by the relation of these two variables to the factor of life age. Two of the regressions proved to be linear and one non-linear, an added difficulty which would render the original correlation not significant, since the correction could not be made for the third variable under such conditions. Similarly, the correlation between rate of growth and life age (non-linear regression) is influenced by the correlation between rate and mental age (linear regression) and the influence of the last-mentioned variable cannot be allowed for by available statistical measures. (I am indebted to Prof. Truman Lee Kelly for an authoritative opinion on this point.)

TABLE 7

Mental age increases of 'improving' subjects.

Subject No.	First life age	First mental age	Net total mental age increases after 1 yr.	after 2 yrs.	after 3 yrs.	after 4 yrs.	after 5 yrs.	after 6 yrs.	after 7 yrs.	after 8 yrs.
44	7	3.7	.1	.2	.4	1.2	1.7	1.9	2.0	2.0
86	7	4.9	1.1	1.5	2.0	2.0	2.0	2.4		
87	7	5.6	.4	.7	1.1	1.2	1.4	1.7		
88	7	5.7	1.1	1.4	1.8	1.9	1.8			
89	7	5.7	.8	1.1	1.3	1.7	1.8			
28	8	3.3	.9	1.1	1.1	1.0	1.2	1.5		
61	8	3.8	.4	1.3	1.7	2.1	2.3	2.4		
62	8	4.0	.3	1.1	1.3	1.5	1.8	2.0	2.2	
90	8	4.4	1.1	1.8	2.2	3.1	3.1	3.2		
91	8	4.5	1.0	1.5	2.2	2.4	2.5	2.5	2.6	2.8
92	8	5.5	.2	.8	1.1	1.6	2.0			
93	8	5.9	.8	1.2	1.1	1.3	1.4			
94	8	6.3	.5	.8	1.2	1.4	1.2	1.4		
132	8	6.6	.6	1.0	1.3	1.4				
133	8	7.0	.2	.4	.6	.7	1.1	1.5		
159	8	7.6	.2	.4	1.0	1.6				
45	9	3.6	1.0	1.6	2.3	2.3				
63	9	4.5	.8	1.5	1.6	1.2	1.5	1.6	1.7	
95	9	4.3	.7	1.5	2.4	2.8	3.0	3.0	3.0	2.8
97	9	6.7	.6	.7	.6	1.0	1.2			
135	9	7.0	.1	.4	.7	1.0	1.2	.9	1.2	1.4
160	9	7.0	.5	.6	1.0	1.3	1.9	2.1	2.2	
161	9	7.1	.3	.6	.9	1.1	1.9			
162	9	8.2	.3	.8	1.1					
137	10	7.1	.5	.7	1.0	1.2	1.5	1.6	1.4	
138	10	7.6	.8	.9	1.0	1.0	1.2			
100	11	5.9	.6	.7	1.3	1.6	1.6			
185	11	8.0	.4	.8	1.3	1.6	2.0			
186	11	8.5	.4	.7	1.5					
67	12	5.1	.9	1.4	1.3	1.6				
166	12	8.4	.1	.3	.8	1.0	1.3			
104	13	6.0	.7	1.1	1.1	1.1	1.1	1.1	1.0	.9
105	13	6.4	.5	.4	.4	1.2	1.3			
167	13	7.5	.5	1.1	1.4	1.4	1.6			
168	13	8.6	.1	.7	1.0	1.2				
170	14	8.4	.4	.9	1.1					
171	14	8.4	.3	.9	1.2	1.0	.8			
194	19	9.4	.4	1.1	1.4	1.4	1.6	1.1	.9	

ages or the less retarded subjects.

The average rates of increase at each life age, independently of mental age, are collected into Table 9. This table shows the average rate at each successive age for the three groups with subjects uncombined and then with subjects of similar ages at any examination combined. We may note from this table that:

1. There is a tendency for the first rates at each age group to be somewhat higher than the succeeding rates. That is, the 8-year-olds at their first record have a higher average than the

TABLE 8

Relation of rate of mental age increase to life age, mental age, and I. Q. among 'improving' subjects.

Section A—Subjects 7 years old at first record

When 7 years old			When 8 years old			When 9 years old			When 10 years old			4-Yr.
M.A.	I.Q.	Rate	M.A.	I.Q.	Rate	M.A.	I.Q.	Rate	M.A.	I.Q.	Rate	Ave.
3.7	53	10	3.8	48	10	3.9	43	20	4.1	41	80	30
4.9	70	110	6.0	75	40	6.4	71	50	6.9	69	0	50
5.6	80	40	6.0	75	30	6.3	70	40	6.7	67	10	30
5.7	81	110	6.8	85	30	7.1	79	40	7.5	75	10	48
5.7	81	80	6.5	81	30	6.8	76	20	7.0	70	40	43
Av. 5.1	73	70	5.8	73	28	6.1	68	34	6.4	64	28	40

Section B—Subjects 8 years old at first record

When 8 years old			When 9 years old			When 10 years old			When 11 years old			
3.3	41	90	4.2	47	20	4.4	44	0	4.4	40	—10	25
3.8	48	40	4.2	47	90	5.1	51	40	5.5	50	40	52
4.0	50	30	4.3	48	80	5.1	51	20	5.3	48	20	38
4.4	55	110	5.5	61	70	6.2	62	40	6.6	60	90	78
4.5	56	100	5.5	61	50	6.0	60	70	6.7	61	20	60
5.5	69	20	5.7	63	60	6.3	63	30	6.6	60	50	40
5.9	74	80	6.7	74	40	7.1	71	—10	7.0	64	20	33
6.3	79	50	6.8	76	30	7.1	71	40	7.5	68	20	35
6.6	83	60	7.2	80	40	7.6	76	30	7.9	72	10	35
7.0	88	20	7.2	80	20	7.4	74	20	7.6	69	10	18
7.6	95	20	7.8	87	20	8.0	80	60	8.6	78	60	40
Av. 5.4	67	56	5.9	66	47	6.4	64	31	6.7	61	30	41

Section C—Subjects 9 years old at first record

When 9 years old			When 10 years old			When 11 years old			When 12 years old			
3.6	40	100	4.6	46	60	5.2	47	70	5.9	49	0	58
4.5	50	80	5.3	53	70	6.0	55	10	6.1	51	—40	30
4.3	48	70	5.0	50	80	5.8	53	70	6.7	56	40	70
6.7	74	60	7.3	73	10	7.4	67	—10	7.3	61	40	25
7.0	78	10	7.1	71	30	7.4	67	30	7.7	64	30	25
7.0	78	50	7.5	75	10	7.6	69	40	8.0	67	30	28
7.1	79	30	7.4	74	30	7.7	70	30	8.0	67	20	23
8.2	91	30	8.5	85	50	9.0	82	30	—	—	—	—
Av. 6.1	67	51	6.6	66	43	7.0	64	36	7.1	59	17	37

TABLE 9

Average annual rates of mental age increase of 'improving' subjects classified by initial life ages.

First age	No.	Rate age 7	Rate age 8	Rate age 9	Rate age 10	Rate age 11	Rate age 12	4-Year average
7	5	70	28	34	28			40
8	11		56	47	31	30		41
9	8			51	43	36	17	37
Combined	24	70	48	42	34	33	17	

7-year-olds at their second record (or when they are 8-year-olds). This seems to indicate some influence which tends either

to make the first annual rate high or the succeeding rates low, over and above the tendency of the rate to decrease as a function of age. This may be accounted for as an influence of practice or experience on the first re-tests (an influence which steadily drops off), or it may be that institutional regime tends either to inhibit the full expression of intelligence, by lessening the demands upon it or by eliminating the exercise of certain intellectual activities. However, the difference is not great in amount, being on the average less than one-tenth of a year.

2. The combined rates show the same influence of age that was shown in Table 6, based on Table 5. The actual averages are slightly higher but not so much as might have been expected. The fluctuations in rate among the non-improving subjects of Table 5 evidently tended to keep the rate up as an average.

3. The results of this treatment of the data confirm the results of the previous mode of treatment in showing that rate of increase is primarily a function of life age. It does not, however, indicate the relation between rate and age of arrest. We therefore proceed to a study of these combined factors.

Average growth curves of the feeble-minded.—We have now demonstrated two marked tendencies in the mental growth of the feeble-minded, namely (1) a tendency for the age of arrest to be associated with the level of arrest and (2) a tendency for the rate of growth to be independent of the mental age. We have seen: (1) that the rate of growth is inconsiderable in the low mental ages; (2) that the rate of growth is primarily a function of life age; (3) that there is some tendency at each age toward a slight *negative* correlation between rate and degree of retardation; and (4) that the high-grade subjects have a lower rate of increase than was expected, which is possibly due to their relatively higher life ages.

But the exact form of the average curve of growth is not clear from the general arguments presented above. It is desirable, moreover, to observe the connection between rate of growth, age of arrest, and level of arrest. The attempt has therefore been made to plot the actual average growth curves of each final mental age group. This is a difficult undertaking and

the results are limited by the small numbers of subjects at some ages. Nevertheless, as will be seen, it is possible to obtain fairly smooth growth curves, although it is not possible to determine their absolute accuracy because of limitations of the data.

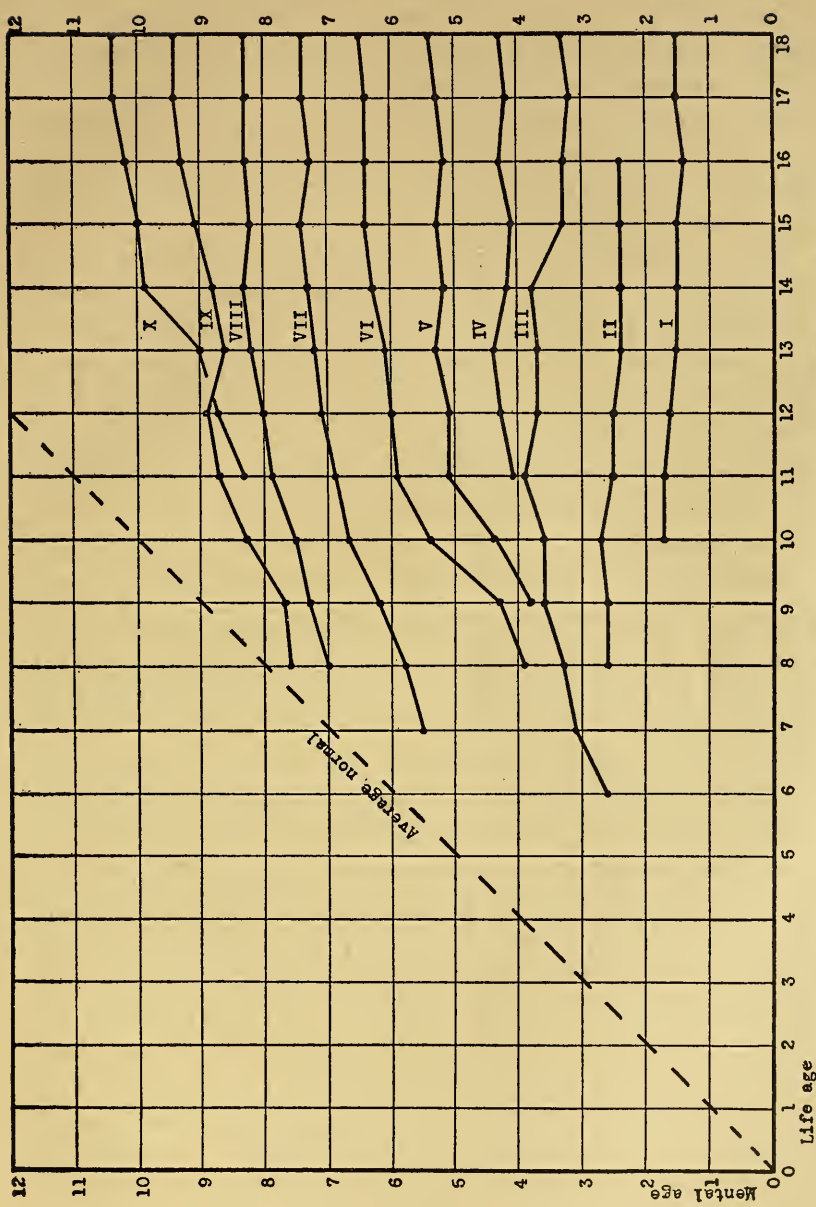
To accomplish the purpose of plotting the growth curves of the several degrees of feeble-mindedness we have attempted to determine the average mental age of each final mental age group at each of its successive life ages. The computations are based on the groupings and data of Table 2. The procedure consists in calculating the actual mental ages of each subject at each of his life ages. The similar ages of each final mental age group are then grouped together and the corresponding mental ages are averaged. The detailed tabulations are not presented, but the average results are shown in Table 10. This table shows for each final-mental-age grouping of subjects the number of subjects at each successive life age (for that group) and the corresponding average successive mental ages of the group. These successive averages constitute the growth curves for each final mental age group. The results are clearer when presented

TABLE 10

Average developmental progress of each final mental age group, showing successive average mental ages at each life age.

	Final M.A.		Final M.A.		Final M.A.		Final M.A.		Final M.A.		Final M.A.		Final M.A.		Final M.A.		Final M.A.	
Life age.	1 yr. No.	Av.	2 yrs. No.	Av.	3 yrs. No.	Av.	4 yrs. No.	Av.	5 yrs No.	Av.	6 yrs. No.	Av.	7 yrs. No.	Av.	8 yrs. No.	Av.	9 yrs. No.	Av.	10 yrs. No.	Av.
6					1	2.6														
7					2	3.1			1	3.7			4	5.5						
8			2	2.6	2	3.3	1	3.3	1	3.8	2	3.9	9	5.8	3	7.0	1	7.6		
9			4	2.6	3	3.6	1	4.2	2	3.8	3	4.3	12	6.2	5	7.3	5	7.7		
10	1	1.7	4	2.7	2	3.6	1	4.4	2	4.4	4	5.4	14	6.7	8	7.5	6	8.3		
11	1	1.7	6	2.5	2	3.9	3	4.1	2	5.1	6	5.9	17	6.9	8	7.9	7	8.7	2	8.3
12	2	1.6	6	2.5	3	3.7	6	4.3	5	5.1	7	6.0	17	7.1	8	8.0	8	8.9	2	8.7
13	4	1.5	6	2.4	3	3.7	6	4.4	6	5.3	8	6.1	22	7.2	8	8.2	8	8.6	2	9.0
14	5	1.5	5	2.4	3	3.8	8	4.2	5	5.2	8	6.3	21	7.3	11	8.3	9	8.8	3	9.9
15	5	1.5	3	2.4	4	3.3	7	4.1	5	5.3	11	6.4	17	7.4	11	8.2	9	9.1	2	10.0
16	3	1.4	2	2.4	5	3.3	7	4.3	7	5.2	9	6.4	17	7.3	10	8.3	9	9.3	6	10.2
17	3	1.5			4	3.2	7	4.2	8	5.3	8	6.4	15	7.4	10	8.3	9	9.4	6	10.4
18	2	1.5			3	3.2	6	4.3	6	5.4	8	6.5	10	7.4	9	8.3	6	9.4	7	10.4

graphically, but in studying the graph one must not ignore the limited numbers of subjects at certain points in the curves. The one-subject 'averages' are not represented on the graph. Fig.



Average growth curves of each final mental age group of feeble-minded subjects.

FIG. 10

10 shows these average growth curves for each final-mental-age group. The curves show the average courses of development at successive ages up to the final level.

These growth curves substantiate our previous arguments from still another point of view. They also show very clearly (subject to limitations of sufficiency of data) the ages of arrest and the annual rates of growth.

We may now determine the average ages of arrest with a fair degree of accuracy. The exact determination will depend somewhat upon the criterion employed. For practical purposes the age of arrest may be taken as the age when (for any curve) the growth curve enters the final mental age year-interval. Even though the curve may have a slight upward trend after this point the net increase is never greater than .5 years. On this criterion the ages of arrest may be given as follows:

Final mental age	1	2	3	4	5	6	7	8	9	10
Age of arrest	?	?	7	11	11	12	12	12	15	15

In terms of the grades of feeble-mindedness we may say that idiots and low-grade imbeciles are arrested probably before 7 years of age, upper-grade imbeciles about 12 years, and morons about 15 years.

The average rates of growth are observed to be practically negligible for final mental ages 1 year to 4 years inclusive after the life age of 6 to 10 years. For final mental age groups 5 to 9 the growth rates are approximately the same between the life ages of 8 and 14 years; the growth curves at these life ages are practically parallel (particularly if we were to smooth the irregularities of the curves for mental ages 6 and 9) and the rates are therefore independent of mental age. For final mental age 10 years the rates of growth for life ages 11 to 15 are about the same in amount as those of mental ages 5 to 9 between ages 8 to 14; that is, the curves of growth are about the same in shape but the former is displaced 3 years higher. At all mental ages where the subjects are young enough to furnish data for the rate of growth the rate is a progressively decreasing variable. Moreover, inspection of Fig. 10 lends color to the theory that

the upper grades of feeble-mindedness have approximately an average normal rate of growth early in life. The higher mental age curves of Fig. 10, if projected to the lower ages, would branch off from the average normal curve considerably after birth, that is, nearly midway in their developmental course. Hence there is no prognostic value in mental age (or in degree of mental age retardation) in the higher grades of feeble-mindedness prior to about 6 or 8 years of age. The average high-grade feeble-minded subject is 'at age' early in life and is only potentially feeble-minded from the standpoint of mental age. Hence, high-grade feeble-mindedness cannot be diagnosed by mental age alone or by a degree of mental age retardation in the younger ages.

Causative factors in feeble-minded growth.—It has not been feasible to include in this study an analysis of the relation of intellectual growth to causative factors and remedial treatment. The general dependence of mental growth upon heredity and environment has not been investigated statistically in this study. The special influences of etiology, medical treatment, and individual physiological anomalies upon the mental development of the mental defectives of this investigation have also been passed by. A systematic analysis of these influences was planned for in the original undertaking, and considerable material was assembled. But this material proved to be too limited and too incomplete to yield positive conclusions. The presentation of this material has therefore been omitted as not falling within the scope of the present study. But certain generalizations, partly theoretical and partly observational, may be outlined as follows:

(a). There is at present no satisfactory explanation of sudden mental arrest in 'at-age' subjects. The most plausible explanation of this type of 'potential feeble-mindedness' is (1) hereditary pre-determination or (2) fundamental disturbances in the endocrine system. None of the instances of sudden arrest in these data are due to traumata or known physiological pathology.

(b). No definite relation is evident (from the unreported material) between types of development and the known facts of heredity or environment. Among the positively hereditary cases

we find all types of development; similarly for subjects from strikingly different environments. Possible *qualitative* differences in intelligence for subjects of different types of parentage or environment are not definitely expressed in these quantitative measurements of gross mental age increases. More careful analysis from better data might yield more positive results.

(c). In traumatic feeble-mindedness there follows ordinarily a complete arrest of intellectual growth. The same effect is also evident, though with more exceptions, where the mental defect is the result of acute disease.

(d). Special medical treatment has relatively little positive effect in bringing about mental growth in these mental defectives, even when the retardation is relatively slight or the subject young. The beneficial effects of thyroid treatment on cretins at certain stages of their development are well-known. No such subjects are present in these data. Several of our subjects did receive pineal treatment, 'double-dose pineal,' pituitary, and 'double-dose pituitary.' The number of subjects who improved noticeably under such treatment is no greater than the number who did not improve under it, and is less than the number who improved markedly without special treatment. The subjects who received these treatments were relatively young and only slightly retarded at the time of treatment.

(e). The factor of institutional environment is not an obvious influence in the mental age growth of these defectives, either positively or negatively. Sudden arrest takes place in good home environment and continued growth occurs within the institution. The possible qualitative effects of institutional life and accompanying educational acquisition are not obvious in these measures of gross mental age growth.

(f). Undoubtedly individual physiology and anomalies in the endocrine system are the most potent factors in individual mental growth. This is not only a plausible expectation from general bio-chemistry, but is suggested by the results of anthropometric measurements and correlated individual physical characteristics.

B. Superior Mental Growth

In a previous section (*cf.* pp. 20 to 23) certain speculations were presented concerning the mental growth of superior children. It will be recalled that the hypothesis was offered that during some age-intervals the rate of growth of superior children tends to increase.

Superior intelligence is defined by Terman as that degree of intelligence which may be expressed as an intelligence quotient which is above 110. An I. Q. above 120 is considered very superior intelligence. Obviously, the final or adult I. Q. will depend upon the level of intelligence which is accepted as the adult average normal. It will also depend upon the efficiency of the measuring scale in determining superior deviations of intelligence. If 16 years is taken as the average normal adult level, then the highest possible ultimate I. Q. (by the Stanford Scale, which measures mental age as high as 19.5 years) is 122. But if 13 years is taken as the average adult level, then the ultimate I. Q. could be 150. But we have already pointed out the difficulties in the way of measuring intelligence in terms of mental ages which are higher than that of the average normal adult.

Of course when the 'average adult' and 'superior adult' levels of the Stanford Scale are employed to represent the mental ages of 16 to 19 years this usage must be recognized as one of convenience only. Terman has recognized this point. He says (31, p. 58): "It will be understood naturally that the numbers expressing such mental ages as 17 years, 18 years, 19 years, etc., have only a conventional value and are not to be interpreted literally. Their use offers a feasible, if arbitrary, method of enabling the superior adolescent or adult to earn a quantitative expression of his superiority in the tests."

If further experimentation should confirm the hypothesis that 13 years is the average mental age of unselected adults then this statement by Terman would apply with equal force to the mental ages of 14, 15, and 16 years as well as those beyond. We have already indicated (p. 14) that Terman's recent investigations tend in this direction. Throughout this study we have used the usual 16-year limit for calculating I. Q.'s.

In either case, whether we adopt the 16-year or the 13-year level, there will be for superior children an age of arrest which is in part determined by the degree of brightness (the I. Q.), in part by life age, and in part by the efficiency limit of the Scale as a measure of intelligence. It is therefore peculiarly difficult to fix the age of arrest among superior children. The final appeal must be repeated tests of the same individuals. It is safe to assume, however, that the age of arrest is probably not earlier than 13 years of age.

The rate of growth of superior children will depend partly upon life age and partly upon the final mental level. As the mental age approaches the upper limit of the measuring Scale the subject finds it increasingly difficult to maintain his rate of development. Hence, after the mental age reaches a certain point we may expect the rate of development to decline. When a 10-year-old subject tests 15, for example, he has more difficulty in maintaining an I. Q. rate of 150 than when he was 6 and tested 9, for the scale becomes increasingly more difficult in the upper ranges, relatively as well as absolutely. He has less and less range of tests over which to register his intelligence. But as long as the mental age remains under, say, 15 or 16 years the rate of growth will be either a function of age, mental age or degree of brightness.

We have seen that the rate of growth for subjects of subnormal mentality is a decreasing variable, that is, the inferiority tends to become more and more pronounced. And we have postulated the converse of this as a speculation regarding superior children, that is, that up to a certain point (determined by the considerations just stated) the rate may be an increasing variable and the superiority may become more and more pronounced.

Re-tests of superior children.—The literature of the subject contains comparatively few reports of repeated tests of superior children. Only a few studies, very limited in scope, are available. We shall review them later. We are, however, fortunate in being able to present some experimental data generously supplied to us by Miss Anna Gillingham, of the Ethical Culture

School, New York City. Miss Gillingham is well qualified in the technique of Binet-Simon examining. She has been a close student of the several modifications of the Binet Scale and has employed the Stanford Revision since its first appearance. In particular she has been a student of children of superior mental ability and her position as principal of the Primary Department and psychological examiner at the Ethical Culture School has furnished her with an ample number of subjects. Miss Gillingham has consented to the use of some of her material in this study. This enables us to use the re-examination records of 39 children whose I. Q.'s were more than 110 at one or the other of two examinations separated by an interval of from one to two years.

We have made certain calculations for 35 of these subjects whose life ages at the first examination are between 9 and 12 years inclusive. For each of these subjects we have calculated the life age increment and the mental age increment from the first to the second examination. The latter divided by the former and multiplied by 100 gives the rate of mental increase for the period covered in terms of a percentage of the average normal rate. These calculations with other data are presented in Table 11.

This table shows for each subject the first life age, first mental age, life age increase, mental age increase, rate of increase (as a percentage of the average normal rate), first I. Q., and I. Q. change. The second life ages may be obtained by adding the life age increment to the first life age. Similarly for mental age. The second I. Q. may be obtained by adding the I. Q. change (retaining sign) to the first I. Q. The subjects are arranged by successive ages 9, 10, 11 and 12 years. They are arranged in order of brightness (I. Q.), which is approximately also the order of mental age, at each age grouping. The averages of Table 11 are summarized in Table 12.

Inspection of Tables 11 and 12 indicates at each life age something of a tendency for the rate of increase to decrease with mental age. Unfortunately the number of cases is very small and renders any statistical treatment inadequate. Treatment is

TABLE 11

Repeated Stanford Binet tests of superior children.

	First life age	First mental age	Life age increase	Mental age increase	Annual rate of increase	First I. Q.	I. Q. change
	9.5	12.1	1.0	.2	20	127	—10
	9.5	12.1	1.0	1.8	150	127	+ 3
	9.0	11.7	1.5	2.2	147	130	+ 2
	9.9	15.6	.9	.3	33	157	—10
	9.7	15.3	1.0	2.9	290	158	+12
Ave.	9.5	13.4	1.12	1.48	128	140	7
	10.8	11.5	1.2	2.1	175	107	+ 6
	10.3	12.0	1.9	4.7	248	117	+20
	10.4	12.7	.9	1.0	111	122	— 1
	10.7	13.8	1.0	3.7	370	129	+21
	10.9	14.1	1.0	2.8	280	130	+12
	10.7	14.1	.9	1.8	200	132	+ 5
	10.7	14.2	1.6	3.3	206	133	+10
	10.4	14.0	1.9	1.5	79	135	— 9
	10.5	14.4	1.2	1.1	92	137	— 4
	10.1	15.3	1.3	.7	54	152	—12
Ave.	10.5	13.6	1.29	2.27	181	129	10
	11.6	11.3	1.2	4.1	342	97	+37
	11.1	12.0	1.1	3.9	350	108	+22
	11.3	11.3	1.3	3.2	246	100	+15
	11.4	12.7	1.3	2.4	185	111	+ 8
	11.4	12.8	1.4	1.9	136	112	+ 3
	11.2	12.9	.9	.2	22	115	— 7
	11.6	13.8	1.1	1.5	136	118	+ 3
	11.3	14.1	1.5	1.9	127	124	0
	11.6	14.4	2.2	1.9	86	124	— 6
	11.3	14.2	2.1	1.9	90	126	— 6
	11.7	15.8	1.1	.1	9	135	—11
	11.1	15.1	1.1	.9	82	136	— 5
	11.5	16.9	1.0	1.6	160	147	+ 1
Ave	11.4	13.6	1.33	1.96	152	120	10
	12.3	13.6	1.1	2.4	218	110	+ 9
	12.7	14.1	.9	2.6	289	111	+12
	12.4	14.4	1.2	.9	75	116	— 3
	12.5	14.8	1.5	1.5	100	119	— 2
	12.4	15.0	1.2	.9	75	121	— 4
	12.8	15.8	1.1	2.8	254	124	+10
	12.4	15.5	1.0	0	0	125	— 9
Ave.	12.5	14.8	1.14	1.59	145	117	7

rendered still more difficult because of extreme variability in the rate of growth. Table 12 shows that the average rate of growth fluctuates with age, being a decreasing variable from ages 10 to 12. But at age 12 the average mental age is higher than at ages

TABLE 12

Average results of repeated tests of superior children, for each life age group.

Ave. first age	9.5	10.5	11.4	12.5
Number of subjects	5	10	13	7
Ave. first mental age	13.4	13.6	13.6	14.8
Ave. life age increase	1.1	1.3	1.3	1.1
Ave. mental age increase	1.5	2.3	2.0	1.6
Ave. rate of increase	128	181	152	145
Ave. I. Q.	140	129	120	117
Ave. I. Q. change	7	10	10	7

10 and 11, hence the 12-year decrease in rate may be due to the observed tendency of rate to decrease as mental age increases.

In view of the unreliability of the average rates (due to individual variability and the small number of subjects at each separate age) it is of some assistance to appeal to correlation coefficients for the entire group of subjects. In doing so we must not, however, lose sight of the limitation of the correlation method when applied to such data.

The Pearson coefficient of correlation between rate of growth and mental age is $r = -.30$ (P. E. .10), and between rate of growth and life age is $r = .058$ (P. E. .113). The correction of these correlations for spurious influence of the correlation between age and mental age ($r = .058$) does not materially change the size of the coefficients. The correlation between mental age and rate when corrected for constriction remains $r = -.30$. The correlation between life age and rate becomes $r = .079$. In the former case the correlation although not high is fairly dependable. In the latter case it is low and undependable.

We may say, then, that in the case of children of superior intelligence between the ages of 8 and 12 years inclusive the rate of development is apparently independent of age, that is, it is fairly constant, except for the influence of mental age. There is only a faint and uncertain tendency for the rate to increase with age. The rate is, however, somewhat related to mental age during these periods. As the mental age increases the rate of growth shows some tendency to decrease over the period of 8 to 12 years. We cannot determine the age of arrest from these data. The rate of growth bcomes increasingly influenced by the upper limits of

the scale and the upper (hereditarily determined?) final mental age of the subject.

We may conclude, then, that in general the rate of growth of intelligence of superior children is conditioned by the mental age (or degree of brightness) during the age 8 to 12 years and is otherwise relatively independent of age during this period. Presumably the rate of growth would decrease after life age 13 years, since the final mental level of superior children is practically attained at that time. At 13 years of age a child of I. Q. 125 would have a mental age of 16.3, beyond which he would find increasing difficulty in obtaining a higher mental age. Even though he continued to develop somewhat, his rate would necessarily fall off rapidly after this point.

III. CRITIQUE OF THE I. Q.

Binet and Simon denied that their Scale had any prognostic value. They defined subnormality in terms of the amount of difference between age and mental age. But they said that without experimental evidence regarding the course of mental growth as determined by successive tests of the same individuals it would be impossible to predict future development from a single mental age determination. They recognized that some retardates might develop and others stand still. They say (2, p. 143): "No actual test can tell us whether an idiot is or is not capable of improvement and to just what point." And again (p. 270) "It is understood that these diagnoses (of grade of feeblemindedness according to age and mental age) apply only to the present moment. He who is an imbecile today, may by the progress of age become a moron, or on the contrary remain an imbecile for life. One knows nothing of that; the prognosis is reserved."

About 1912 a group of German psychologists employing the Binet Scale expressed dissatisfaction with Binet's method of expressing intelligence retardation in terms of the absolute difference between age and mental age. Bobertag (4) clearly expressed objections to the use of this difference. He presented results to show that the distribution of mental ages at each successive life age from 7 to 12 years shows progressively more and more 'spread', that is the curves of mental age distribution at successive life ages become progressively flattened out. In other words the range of variability in years of difference becomes more extended with increase of age. Or, in statistical language, the P. E. of the mental age distribution increases in size with increase of age. A deviation of two years above or below the median at age 12 was found to occur about as frequently as a deviation of one year at age 6. Hence retardation expressed as an absolute difference between age and mental age was found to be progressively less and less significant with increase of age. To overcome this difficulty Bobertag proposed to use the *ratio* of

mental age to life age as a more adequate expression of retardation. This was termed the 'intelligence quotient' or 'I. Q.' Bobertag gives Stern credit for devising and naming this device, but Stern acknowledges his indebtedness to Kramer, Chotzen and Bobertag.[11] Undoubtedly the I. Q. is, for the reasons given by Bobertag, a much more satisfactory way of expressing retardation than the method of absolute difference.

About the same time Kuhlmann independently came to substantially the same conclusions, but from apparently different premises. Kuhlmann gives two reasons for employing relative retardation. "One is that the rate of normal mental development decreases with age. Mental progress is rapid for the first few years and becomes slower as maturity approaches" (22, p. 136). This, he believes, is a justifiable premise on the ground of an assumed 'rough relationship' between functional mental development and growth in brain weight. Kuhlmann's second argument is that "the younger the child is, the less time he has had to fall behind the normal in development." Later in life, the increments of retardation which may have been slight from year to year have accumulated into a large total amount.

Terman has been the strongest advocate of the I. Q. He has also produced more evidence than other writers to justify its use. We believe, however, that his enthusiasm has developed a too optimistic faith in its validity and properties which is not entirely warranted by the facts.

Terman favors the ratio of mental age to life age (instead of the difference) as an expression of retardation on the same grounds as does Bobertag. He argues that the median deviation of mental age increases with increase of age. At life age 12. for example, the median deviation of mental age is 2 years whereas at age 6 it is only 1 year. In other words, the significance of 1 year of retardation at age 6 is no greater than 2 years at age 12. On the other hand he finds that this is not true when the mental age distributions are replaced by I. Q. distributions.

[11] One finds it difficult to dissociate the work of these four investigators. Their joint work constitutes a coherent whole, the work of each supplementing that of the others. The work of Bobertag is the most pertinent for present purposes.

In terms of I. Q. the median deviation is approximately constant for the succession of life age groups.

This point may be rendered clear by a statistical table based on Terman's results. Table 13 shows the median life ages, median mental ages, median I. Q.'s, probable errors of mental age and probable errors of I. Q.'s for Terman's unselected school

TABLE 13

Mental age deviation by the Stanford Binet Scale

No. of subjects	Median life age	Median mental age	Median I. Q.	P. E. of M. A.	P. E. of I. Q.
16	4.0	4.1	103	.41	10.3
54	5.0	5.5	109	.44	8.8
117	6.0	6.2	103	.48	8.0
93	7.0	7.3	104	.60	8.5
98	8.0	8.2	102	.62	7.7
113	9.0	9.1	101	.69	7.7
87	10.0	10.3	103	.77	7.7
79	11.0	11.2	102	1.02	9.3
83	12.0	11.9	99	1.26	10.5
98	13.0	12.9	99	1.20	9.2
82	14.0	13.9	99	1.16	8.3
47	15.0	13.5	90	1.16	7.7
14	16.0	12.8	80	1.34	8.4

children. The table is made up from calculations based on graphs 1 to 11 of Terman's monograph (31). The column of Table 13 headed "P. E. of M. A." shows the probable error (median deviation plus and minus) of each median mental age, that is, the range above and below the median which includes the middle 50 per cent of subjects when arranged in order of ascending mental age values. Similarly for the column headed "P. E. of I. Q."

The P. E. of M. A. values are observed to increase steadily and regularly with increase of life age from about .4 at age 4 to about 1.2 at age 12. This means that a deviation plus or minus of 1.2 occurs as frequently at age 12 as a deviation plus or minus of .4 at age 4. In other words, a deviation of 1.2 years of mental age at age 12 has (for average normal unselected subjects) the same significance as a deviation of .4 years at age 4.

The values of P. E. of I. Q. on the other hand are fairly equal at all successive ages, ranging from approximately 8 to approximately 10 points. In other words, the median deviation from

the standard I. Q. is about the same at all ages, being on the average about 8.5 points I. Q.

Therefore, it is argued (the course of Terman's argument being slightly different from ours) that the I. Q. is a better unit of mental deviation than is the amount of difference between actual mental age and the standard mental age for any given life age.

Thus far the argument is fairly obvious and sound. It is clear that the I. Q. furnishes a better unit of deviation than does the amount of difference between actual mental age and standard mental age *when it is a question of determining relative brightness or the significance of retardation or acceleration.* But we cannot go so far as to conclude from this single merit of the I. Q. that, "The mental age of a subject is meaningless if considered apart from chronological age. It is only the ratio of retardation or acceleration to chronological age (that is, the I. Q.) which has significance" (30, p. 68).

Mental age is an absolute measure and has great significance even apart from age, although, to be sure, one may not ignore life age. If we know that the mental age of an individual is 10 years, for example, we know, whatever his chronological age may be, that he could (at the time) probably do about 4th grade school work, could learn any of the simple manual arts and trades, could master the relatively unskilled industrial occupations, could control his own conduct and work with only a small amount of supervision, and so on. Of course we would want to know his actual life age, his degree of brightness, his intellectual maturity and activity, his physical condition, temperament, personal history and so on, but even without these latter facts his mental age would tell us a very great deal about his actual and probable scholastic, industrial, and social capabilites.

But suppose we know only that the I. Q. of an individual is 100. We then know only that he is of average normal brightness. Not knowing his absolute mental age, whether it is 5, 10, or 15 years, we cannot say anything about his capabilities. Or suppose his I. Q. is 50. We would know he is probably feeble-minded but we would not know of what degree, whether idiot, imbecile or moron. Therefore, while the I. Q. is admittedly valuable as a measure of brightness, if we use it apart from age or mental age it tells us nothing about capabilities *pro tem.* Of course *neither* mental age nor I. Q. should be used apart from life age, but if life age is to be ignored it is the I. Q. which loses meaning and not the mental age.

The errors to which the uncritical use of the I. Q. may lead are many and serious. Terman for example concludes (30, p. 67): "The traditional view that variability in mental traits becomes more marked during adolescence is

here contradicted, as far as intelligence is concerned, *for the distribution of I. Q.'s is practically the same at each age from 5 to 14 years.*[12] For example, 6-year-olds differ from one another fully as much as do 14-year-olds." But we have just shown (*cf.* Table 13) that in terms of absolute intelligence individual differences in mental age constantly increase. The P. E. of M. A., which is the measure of variability in actual intelligence, is at age 14 almost exactly three times as great as at age 4. It is only when we have changed these absolute units to relative units that individual differences are found not to increase with age.

Many studies in the field of juvenile delinquency cannot properly be evaluated because the results are expressed only in I. Q. terms without accompanying data in regard to the ages of the subjects (*cf.* for example various studies in the *Journal of Delinquency*). It is possible that types of crime are related to the intelligence of delinquents. What are the crimes committed by an I. Q. of 75, for example? The answer will depend on whether the I. Q. is obtained from the ratio 12/16 or 9/12. Or suppose it is a question of diagnosis, and suppose the investigator has used an upper mental age limit which is unacceptable to some authorities. The question immediately arises concerning the number of subjects who were above the mental age limit in question. This question cannot be answered from an I. Q. frequency distribution if it is unaccompanied by a statement of life ages or mental ages.

It is therefore obvious that we cannot afford to ignore the actual mental age or life age from which an I. Q. is calculated. To do so may invalidate a study on the basis of classification. The I. Q. may be a practical unit for measuring 'brightness' at a given age or for comparing degrees of brightness at different ages. But it cannot serve as a satisfactory measure of degree of intelligence independently of the ratio from which it has been derived. These fairly obvious objections to the I. Q. have been repeatedly pointed out but seem to have been generally ignored.

Constancy of the I. Q.—We have seen that the I. Q. is valuable as a measure of relative brightness, and as a unit of mental deviation. Its significance is superior to mere difference between age and mental age as a measure of retardation.

What is the value of the I. Q. as a prognostic device, that is as a means of prediction? What is its value as a means of ultimate diagnosis or classification of such significant intellectual types as feeble-minded or gifted children? May it be used as a predictive measure of *rate* of development?

[12] Italics ours.

We have showed that the I. Q. as the probable error of mental age is approximately constant at all ages. In other words, the I. Q. distributions are practically identical at all ages from 4 to 14. It follows as a corollary that *on the average* the I. Q. is constant as a measure of rate of growth during the ages 4 to 14 years. This is because the average normal annual mental age increment from age to age is approximately 1 year. This is a consequence of the empirical nature of the standardization of the measuring scale, which is so devised that each median mental age will equal its corresponding median life age. Hence the median annual increment is always 1 year (from ages 4 to 14).

We define rate of growth as this annual mental age increment, that is, the amount of mental age increase divided by the corresponding life age increase. Since for the average normal subject this increment is on the average 1.0/1.0 we may convert other rates to a percentage of the average normal by multiplying a given rate by 100. Thus if a subject gains .5 years in one year his rate of increase in terms of a percentage of the average normal subject is: $\text{rate} = \frac{.5}{1.0} \times 100 = .50$ per cent (of the average normal annual rate).

An objection might be raised against this definition on the ground that the actual rate of growth is not 100 at all ages. The actual median rates (calculated from Table 13) are as follows:

Age-interval	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Median rate	140	70	110	90	90	120	90	70	100	100

That the actual rate is not 100 is, however, only an experimental inaccuracy of standardization. The principle of standardization calls for a rate of 100 which is only approximately obtained by experiment.

Another objection is that the average rate of growth after age 16 (or after 13 if we accept Doll's hypothesis) is found to be 0 instead of 100, since after this age there is no increase in mental age level of higher age groups. But for experimental purposes it was necessary to assume continuous growth to an indefinite age. It was conceivable that the feeble-minded might continue to increase in mental age after the age at which average normals cease to increase.

We have not been free to use the I. Q. as a measure of rate of increase because this would have committed us to certain assumptions whose very validity we intended to question. More-

over, the I. Q. tends to obscure fluctuations in rate of increase *because the variations are distributed over a period of years.* The I. Q. is always a *total average* rate for the age of the subject. Hence the fluctuations in mental growth from year to year are 'ironed out' by the I. Q. mode of expressing mental growth. This ironing out or 'smoothing' process becomes more and more effective as age increases. Suppose a child at the age of 9 years has a mental age of 9, which is an I. Q. of 100. And suppose that during the next year this child makes absolutely no mental age gain. His I. Q. at 10 years would then be 90. The loss of I. Q. would be only 10 points. Yet the loss in actual rate of growth is 100 points, for the 9-year I. Q. rate has dropped from expected 100 to actual 0. This loss of 100 points is by the I. Q. method spread over the entire 10 years, giving an apparent loss in rate of only 10 points for the year. If this hypothetical child were then to gain 2 mental years from age 10 to age 11 his I. Q. gain would now be only 10 points; although he would actually be gaining at twice the normal rate, or 200 per cent, this rate would be minimized in the I. Q. The irregular development of this subject from 9 to 11 years showing first absolute arrest and then twice normal gain would appear only as a slight irregularity in his growth by the I. Q.'s.

Hence it follows that the I. Q. is not a valid measure of rate of growth since it distributes variations over a period of years instead of measuring them only for the time-interval under consideration. It also follows that apparently slight variations in I. Q. such as would be considered 'approximately negligible' may actually be on the contrary very significant. It also follows that equal amounts of I. Q. variation have different meanings as measures of rate of growth according to the ages of the subjects. Thus, zero increase in mental age between 3 and 4 years of age would effect an I. Q. reduction of 25 points for that interval (assuming I. Q. 100 at age 3), while between 13 and 14 years the reduction would be only 7 points. And we have seen that while the median rate of mental age increase may vary from age to age this variation is not evident in the I. Q.

Literature on the constancy of the I. Q.—Bobertag was one

of the first to conduct re-examinations of the same subjects (4). His results showed that the Binet Scale (1908 version) is valid for this purpose. He found no significant influence of memory or 'practice' from the first examination. His results showed a close relation between the mental age ranks of the first and second examinations, a correlation of R = .95. Moreover, the 'at-age' children (retardation or acceleration less than 1.0 year) gained on the average 1 year in mental age during 1 year of time, the retarded children gained only two-thirds of year, and the superior children gained a year and a quarter (4, pp. 521 ff). His results also showed that the older subjects (11 and 12 years of age) gained less than the younger subjects (7 and 8 years of age). This result he ascribed to the increasingly narrow range of tests in which the older subjects could register improvement. This tends to explain the fact that 1 subject dropped from 'accelerated' to 'at-age,' and 4 subjects from 'at-age' to 'retarded.' Unfortunately the actual ages of his individual subjects were not presented for each test-age and it is therefore not possible to determine the rate of growth at the different ages. Bobertag concludes (p. 528): "Children whose intelligence is above average gain more rapidly than those whose intelligence is average, while those below average gain more slowly than those who are average. Therefore, the difference from the average plus and minus must increase with increase of age. Also, within the group of those who are average it must come about that some who are average must become retarded and some become advanced (in units of the difference between the actual mental age and the standard mental age for the life age of the subject)." Bobertag employs this conclusion as an argument in favor of the use of the I. Q. ratio in preference to the difference between mental age and life age. He also contends that the I. Q. must be used in place of mental age difference for designating feeble-mindedness and the several grades of feeble-mindedness.

But with regard to the constancy of the I. Q. as a measure of individual development from year to year Bobertag has this to say: "If one limits himself to a few successive ages, *e.g.*, 8, 9 and 10 years, then one would be warranted in calculating in

each case after the manner just described (for employing the I. Q.). One would then be able to say that the I. Q. is approximately constant, being about .75 for moronity and about .65 for imbecility (the exact figures being for the moment immaterial). But if one reviews a *series* of ages, such as the entire period of the child's development of intelligence, then it is very questionable whether the hypothesis that the I. Q. is constant is valid." He then proceeds to raise several objections against the assumption of the I. Q. being a constant in individual development, to wit:

(1). The younger the child the more difficult it is to determine individual differences in intelligence. Individual differences in a scale of mental tests are so small in amount early in life that one cannot measure them with a high degree of accuracy, although later in life it is possible to do this. It is therefore hardly possible to diagnose feeble-mindedness in children who are very young. And the less the degree of subnormality the more difficult it is to effect diagnosis early in life. And the same is true of supernormal children.

(2). The idea of feeble-mindedness as a condition of hereditarily limited development of intelligence lends color to the theory that among the feeble-minded intelligence growth becomes uniformly more and more retarded, "like the progress of a stone thrown vertically into the air." Mental defect, therefore, is not absolute from age to age but increases relatively with increase of age (although there is a lack of positive data to prove the point).

(3). The results of Chotzen with children from the *Hilfschule* show a decrease in I. Q. from age to age for children who are more than 3 years retarded mentally.

From these considerations Bobertag concludes that the growth curves of the feeble-minded are not retarded by an amount which is constant from birth to maturity but follow the course of a decreasing variable. And he finds this to be true whether the growth curve of the average normal subject is taken as a straight line or as a curved line (*cf.* our Figs. 1, 2 and 3). He concludes his analysis with a graph showing the comparative growth curves

of moron feeble-mindedness, assuming I. Q. as a constant or as a decreasing variable. In the latter case the moron has at age 4 an I. Q. of 85, at age 8 an I. Q. of 75 and at age 12 an I. Q. of 67.

Stern (28) recapitulates the work of Bobertag, Kramer and Chotzen but adds little to it. In our judgment Bobertag's is the clearer exposition. Stern's argument regarding the constancy of the I. Q. applies principally to the feeble-minded. He finds that the I. Q. is a better expression of mental retardation than is the difference between mental age and life age. But from a survey of the work of Chotzen, Kramer and Bobertag he concludes as follows (28, p. 83 f.): "The quotient does not seem, however, to afford an actually constant expression of degree of feeble-mindedness, but shows a tendency to fall in value as age increases. This tendency, it is evident, is but slight within the limits of age that have been mentioned (8 to 12), so that for many problems it can be neglected. Before and after these ages the fall in the value seems to take place more rapidly. In the case of the later age-levels this is easily intelligible, for once the stage of arrest . . . is reached . . . the quotient . . . must decrease as chronological age increases. The feeble-minded child, it must be remembered, not only has a slower rate of development than the normal child, but also reaches a stage of arrest at an age when the normal child's intelligence is still pushing forward in its development. . . . From these considerations it follows that the intelligence quotient can hold good as an index of feeble-mindedness only during that period when the development of the feeble-minded individual is in progress. The above-mentioned gradual tendency of the mental quotient to sink during the progress of development shows that this development approaches the final level of arrest at a progressively decreasing rate. Whether we shall succeed in finding a formula for a truly constant coefficient of feeble-mindedness must be left for the future." He quotes Kramer as doubting the possibility of accomplishing this.

This position of Stern with respect to the age of arrest and the decreasing rate of development is fully supported by our

own experimental investigation on re-tests of feeble-minded. But we may add that *the I. Q. is apparently constant at certain age-intervals only because a short segment of a somewhat flat curve approximates a straight line.* Moreover, the I. Q. sinks only gradually even after the age of arrest because, as we have pointed out, the true loss in rate of growth is minimized by the I. Q. mode of expressing rate of growth. It should also be recalled that Stern is writing of the *average* feeble-minded types and not of individual feeble-minded subjects. For the individual subject the rate of retardation is sometimes a rapidly decreasing variable, sometimes a slowly decreasing variable and sometimes a constant.

Kuhlmann (22) developed the principle of the I. Q. on grounds different from those of Bobertag and Stern. Kuhlmann bases his principle of the ratio of mental age to life age on two main assumptions, namely, (1) that the rate of mental development is not a decreasing variable but is constant through a succession of ages, and (2) that "feeble-mindedness is simply a retarded rate of development whose ratio to the normal remains constant" (p. 138 f.). He recognizes that the first of these assumptions is somewhat in error and is contrary to his own previous argument that the rate of growth (in absolute units) is a decreasing variable. Kuhlmann adopts an empirical scale of average normal mental ages which are identical age for age with their corresponding life ages. Assuming that the feeble-minded rate is at all ages a constant ratio to the average normal rate, he works out a scale of mental ages for these ratios. "The practical usefulness of this scale depends not on whether it is entirely correct, but on whether it represents the facts more closely than we can determine readily in any other way" (p. 140).

In a later article (23) Kuhlmann questions the conclusions of Bobertag and Stern that there is an age of arrest for feeble-minded subjects which is sometimes prior to 15 years. He states that this is an assumption having no warrant in fact and that his own data "rather indicate that many cases continue to develop, some even beyond the age of fifteen." He also challenges Bobertag's conclusion that feeble-minded subjects develop at a rate which steadily decreases.

Terman has from the first emphasized that the I. Q. is a constant, at least for ages 4 to 14 years, if the I. Q. is based on the Stanford Scale. In his *Measurement of Intelligence* (30) he says (p. 63): "Re-tests of children by the Standard Revision have been found to yield intelligence quotients almost identical with those secured from two to four years earlier by the same tests. Those who graded feeble-minded in the first test graded feeble-minded in the second test; the dull remained dull, the average remained average, the superior remained superior, and always in approximately the same degree. . . . The average difference between the I. Q. obtained in the second test and that obtained in the first was only 4 per cent (4 points I. Q.) and the greatest difference found was only 8 per cent."

In a later work (31), while maintaining that the I. Q. tends to remain approximately constant on the average as determined by re-tests of individual children, he says (p. 56): "The most marked exceptions to this rule are found with the feeble-minded, whose intelligence quotient shows a tendency to decrease considerably."

The data upon which these conclusions were based are not presented in either publication and we are therefore unable to evaluate them. But in a more recent work (29) data are presented which show the results of repeated tests with 315 children. Forty-six subjects had been examined 3 or more times. "In case of a child tested several times, each test has been compared with each of the others; for example, the first test with the second, third and fourth separately, the second test with the third and fourth separately, and the third test with the fourth" (p. 138). This mode of treatment yields 120 I. Q. comparisons for the 46 subjects tested more than twice, or a total of 435 I. Q. comparisons at intervals of from one day to seven years as follows:

Less than 1 year	86
1 to 3 years	138
3 to 5 years	85
More than 5 years	127

The ages of the subjects, counted at the time of the earlier of two compared tests were as follows:

3 to 5	99
6 to 8	139
9 to 11	134
12 to 14	55
Above 15	8

A table is presented (p. 141) showing the relation of I. Q.-change to time-interval between tests, age at first test, and I. Q. It is apparent from this table that I. Q. change is almost wholly independent of time-interval, age, or degree of brightness. The table is summarized as follows (p. 142):

"(1) The central tendency of change is represented by an increase of 1.7 in I. Q.;

(2) The middle fifty per cent of changes lies between the limits of 3.3 decrease and 5.7 increase;

(3) The probable error of a prediction based on the first test is 4.5 points in terms of I. Q."

Another table shows the correlation distribution of I. Q.'s at first and second tests. The correlation between I. Q.'s is $r = .933$. There are no marked differences in the medians of either series. At each I. Q. interval, however, there are approximately twice as many subjects whose second I. Q. is 5 points or more above the first I. Q. as there are subjects whose second I. Q. is 5 points or more below the first I. Q., indicating a constant tendency for the I. Q. to increase at the second examination.

The author points out that there are few feeble-minded subjects and that these are relatively high-grade types. Hence it is recognized that: "It is possible that feeble-minded children testing below I. Q. 60 are less likely to hold their own than those of milder degree of defect." It is also pointed out that superior I. Q.'s may be expected to decrease after 13 or 14 years because their mental ages will be higher than the Scale can adequately measure. But in a succeeding chapter (p. 191) it is stated that: "re-tests of superiors show that the I. Q. is more likely to increase" in spite of the tendency for I. Q.'s of the

older superior subjects to decrease. "The central tendency [of I. Q. change for superior children] was toward a gain of 2.08 points."

Significance of I. Q. changes.—It must be recognized from this brief summary of Terman's latest work that for his data at least the I. Q. is approximately constant on the average and is practically independent of age, mental age and time-interval. But we may well question two aspects of the I. Q. It is only *approximately* constant and only constant *on the average*. If we desire to apply the I. Q. to individual subjects as a measure of predictive rate of growth we must know the *probability* of constancy and the meaning of approximateness.

We have already pointed out that absolute mental age is more significant for practical purposes than I. Q., the former being a measure of present or actual capability while the latter is a measure of deviation and (when constant) of ultimate or potential capability. Given an I. Q. 100, for example, we do not know in what school grade such a child belongs, but given a mental age of 10 years we can say he belongs (other considerations aside) in the fourth school grade.

We have also pointed out that slight variations in successive I. Q.'s may be accompanied by marked variations in annual rates of development. In our Table 5, for example, the I. Q. is within 10 points (plus or minus) of the rate only in about 20 per cent of subjects.

Complete absence of mental age increase between 3 and 4 years of age brings a decrease of 25 points in I. Q. while complete absence at 15 to 16 brings a decrease of only 6 points (*cf.* p. 91). Hence the significance of I. Q. deviation depends upon the age of the subject. A gain of 5 points after 10 years of age indicates a marked change in rate of mental age increase while before that age it is progressively less and less significant. Hence the curve of mental age growth may be very irregular while the I. Q. is slightly modified, or it may be regular and the I. Q. obviously modified, according to the age of the subject. If 'nascent stages' occurred they might be completely lost sight of even when I. Q. is approximately constant over a long interval. Thus

a subject who made 100 per cent progress up to 10 years of age and 50 per cent thereafter would at 15 years have lost only 17 points I. Q. Another subject with I. Q. at 100, for example, might make no gain from 10 to 12 and then double gain from 12 to 14 (a 'nascent stage') and yet have an I. Q. constant at 100 for both ends of the four-year period, and varying only by 17 points at the middle of the period.

The significance of I. Q. deviation and a criterion of approximate constancy of the I. Q. may be derived empirically somewhat as follows. The principal age ranges within which the I. Q. is considered constant are from, say, 6 to 14 years. If we admit that a deviation of 50 per cent from the average normal annual rate of growth is a significant deviation then we obtain during successive years the following significant I. Q. deviations:

Life age	6	7	8	9	10	11	12	13	14
Significant I. Q. deviation	8	7	6	6	5	5	4	4	4

In other words, for the range of ages as a whole an I. Q. deviation of about 5 points plus or minus will register a change of 50 per cent in the average normal annual rate of mental age increase. For feeble-minded subjects a lesser I. Q. change would signify an equally significant change in rate while for superior subjects a higher change would be necessary. If a subject's I. Q. had been constant at 50 up to 10 years of age and his rate were then reduced 50 per cent of its constant value, this would be indicated by a loss of only 2 points in I. Q. at age 11. On the other hand a superior subject developing at a constant I. Q. 150 until age 10 and then increasing that rate 50 per cent of its value would show an I. Q. gain of 6 points in I. Q. at age 11.

In general, then, an I. Q. change of 5 points or more is a significant I. Q. change. That is, we may define approximate I. Q.'s as those which change by less than 5 points. A deviation of 10 points is very significant if the life age is high (above 10) or if the I. Q. is low (below 75).

Stating the matter statistically instead of by empirical argument we may say that any deviation greater than P. E. is sig-

nificant. The P. E. of I. Q. change for Terman's data is 4.5 points (29, p. 142), which is the same as we get by practical deduction.

Assuming, then, that an I. Q. change of 5 points is a significant deviation, how frequently will it occur? Terman has calculated both the theoretical frequencies and the actual frequencies for several multiples of P. E. (29, p. 148). The actual probabilities are 1 to 1 (50 per cent) that the I. Q. change will not be more than 5 points plus or minus; 5 to 1 that it will not be more than 10 points plus or minus; and 16 to 1 that it will not be more than 15 points. Or: "We may say, roughly speaking, that the chances that an I. Q. will either increase as much as six points or decrease as much as four points are one in two; that it will either increase as much as twelve points or decrease as much as eight points, one in five; that it will either increase as much as eighteen points or decrease as much as twelve points, one in twenty; that it will increase as much as twenty-four points or decrease as much as sixteen points, one in a hundred and forty" (29, p. 149).

In brief, *every second child has a significant I. Q. change, every fifth child a very significant change, every twentieth child an extremely significant change,* and so on. Or, *the I. Q. is approximately constant only for every other child;* that is to say, *the rate of growth of every other child changes as much as 50 per cent of the average normal rate for a single year.*

But there is a fallacy in this argument. A deviation of 5 points over a period of one year has not the same significance as a deviation of 5 points over a period of 5 years. Hence the meaning of approximateness depends upon the time-interval between tests. A child with an I. Q. of 100 at age 6 who developed at a rate of 50 per cent thereafter would lose 23 points in 5 years, having an I. Q. of 77 at age 11, while a child 10 years old under the same conditions would lose only 17 points. But if a 50 per cent loss in rate of growth for one year is serious, such a continued loss for 5 years would be very serious indeed. Hence, 17 points loss after 5 years would be a certain multiple of the 'seriousness' of 5 points less in 1 year.

Refutation of the constancy of the I. Q.—We may now briefly review our own experimental data in relation to the I. Q. We have shown that 63 per cent of all our feeble-minded subjects who are under 15 years of age at first examination do not improve mentally as much as one year in at least 3 to 5 years. The individual average annual rate of development for these subjects in most cases is less than 20 per cent. This is in spite of the fact that most of the first I. Q.'s of these subjects at the first test range above 50. Nearly two-thirds of the subjects under 15 make no more mental progress than do the subjects who are 15 years and older.

We have also shown that this arrest of development is a function of the final mental age of the subjects, and that the rate of development, even for those subjects whose mental age is increasing, decreases regularly (on the average) with age from 8 to 14 years. Our Table 5 has shown that at any age there are never more than about 20 per cent of subjects whose I. Q.'s agree within 10 points plus or minus with the corresponding annual rates of growth. And our Table 7 has shown that even for the 37 per cent of subjects under age 15 who are increasing in mental age at least one year in five the I. Q. after 4 years is at least 10 points lower in more than half of the cases. And we have shown further that I. Q. change in the feeble-minded is independent of mental age except for a tendency for more *low-grade* feeble-minded than high-grade to maintain an approximately constant I. Q.

On all these issues our data are superior to other data on feeble-minded subjects yet published and certainly make tenable the hypothesis that for feeble-minded subjects the I. Q. is on the average a steadily decreasing variable after the age of at least 8 years. This hypothesis was advanced by Bobertag and Stern in 1912. It was also advanced by Goddard at the same time and received confirmation in a preliminary report of the present data in 1913 (*cf.* 17). The clinical applications of this point of view are admirably presented in a recent article by Mateer (25) which is in certain respects a more detailed critique of the clinical value of I. Q. than we have felt free to undertake in this study.

With respect to superior children our data are distinctly limited. Yet we have been able to show marked discrepancies between the I. Q. predicted rate of growth and the actual rate of growth, for relatively short time-intervals (one to two years). Among 35 children with I. Q.'s above 110 we found rates of mental age increase varying from zero to plus 350, in the latter case the rate being 3 times the predicted rate. Moreover, we also found the average rate of growth at ages 10, 11, and 12 to be distinctly higher than the average I. Q., showing a tendency for the superiority to increase.

Results similar to ours for the feeble-minded may be cited from the literature. Goddard (15) found that after three annual examinations of 346 feeble-minded children 32 per cent had made 'no variation whatever,' while 67 per cent varied less than 0.5 years. Only 28 per cent seemed to have made some progress but in many of these cases the progress was only due to 'normal variation of the abnormal mind.' Only 6 per cent gained more than 1.0 years in the two years covered by the three testings. These were all 'younger cases' (17). Since Goddard's subjects were distributed about equally above and below 15 years, his results would show that about 10 to 15 per cent of his subjects who were below age 15 had improved more than 1.0 year in 2 years. Similarly, about 85 to 90 per cent of those who were below 15 years improved at a rate of less than 50 per cent of the normal.

Berry (1) also reported results in 1912 on re-tests. His subjects were 42 normal public school children, principally 8 and 9 years old, and 40 institutional feeble-minded, aged 9 to 24 years. The normal subjects made an average gain of 1.0 year, average deviation .26 years, with individual gains ranging from .4 years to 1.8 years. The feeble-minded subjects (mental ages 4 years to 11 years) made an average gain of .5 years, average deviation .31 years, with individual gains ranging from —.6 years to +1.2 years. Four subjects, all under 15 years of age, gained 1 year or more, which is a rate of increase considerably higher than the I. Q. prediction for these subjects whose I. Q.'s were presumably below 75. (A similar result is also shown in several of our own

subjects, 9 of whom gained at the rate of 90 to 110 for a single year).

Individual irregularity of development.—An excellent report of mental growth of the feeble-minded was published in 1915 by the Bureau of Analysis and Investigation of the State of New York (26). The ages and mental ages of 52 *borderline* feeble-minded subjects are shown graphically in such a way as excellently to illustrate the marked differences in growth of the individual subjects. These graphs are reproduced here as Fig. 11. From

TABLE 14

Results of repeated tests of borderline feeble-minded; sample treatment of first 10 subjects in reference (26).

Subject No.	Life ages	Mental ages	I. Q.'s	Life age increases	Mental age increases	Annual rates of increase	I.Q. changes
1	3.6	3.0	83				
	4.8	4.6	96	1.2	1.6	133	+13
	5.7	5.2	91	.9	.6	67	— 5
2	5.7	5.0	88				
	7.4	7.0	95	1.7	2.0	118	+ 7
	8.4	7.6	91	1.0	.6	60	— 4
3	6.0	6.0	100				
	7.0	7.0	100	1.0	1.0	100	0
	7.9	8.2	104	.9	1.2	133	+ 4
	9.0	9.0	100	1.1	.8	73	— 4
4	5.1	4.4	86				
	6.1	5.2	85	1.0	.8	80	— 1
5	4.3	3.6	84				
	5.2	3.8	73	.9	.2	22	—11
	6.3	5.6	89	1.1	1.8	164	+16
6	6.4	4.4	69				
	7.3	6.0	82	.9	1.6	178	+13
	8.4	7.0	82	1.1	1.0	91	+ 1
8	8.0	7.0	88				
	8.8	7.4	84	.8	.4	50	— 4
	9.8	7.2	74	1.0	—.2	—20	—10
9	4.5	3.4	76				
	5.5	4.8	87	1.0	1.4	140	+11
10	8.5	6.2	73				
	9.3	7.0	75	.8	.8	100	+ 2
	10.3	7.2	70	1.0	.2	20	— 5
11	9.8	8.0	82				
	11.2	8.8	79	1.4	.8	57	— 3
	12.2	10.2	84	1.0	1.4	140	+ 5

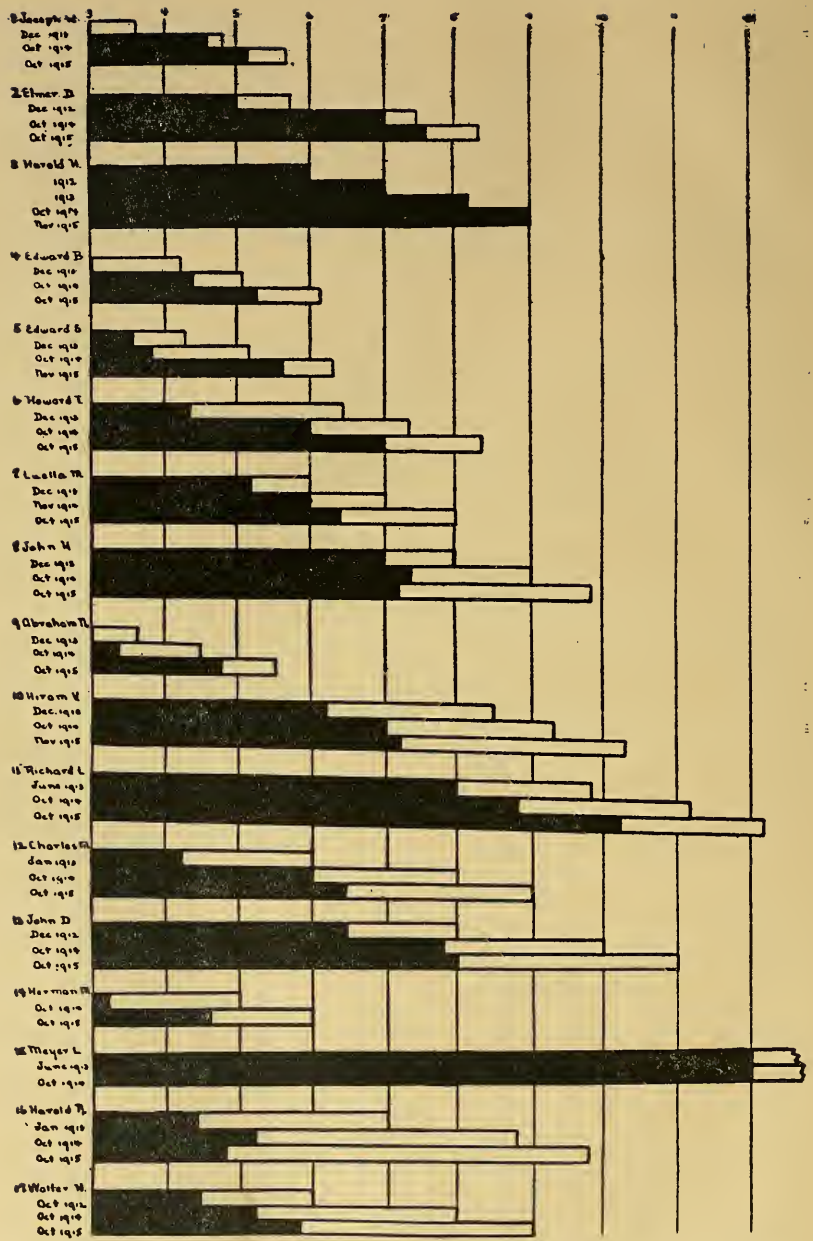


CHART SHOWING MENTAL AND PHYSICAL AGES OF 52 CHILDREN WITH DATES OF EXAMINATION. NOS. 1-17.

Mental age development in 'borderline' subjects showing irregularities in rate of development with consequently variable I. Q.'s. Shaded areas show mental ages, unshaded areas life ages. (From ref. 26.)

FIG. 11—Section A.

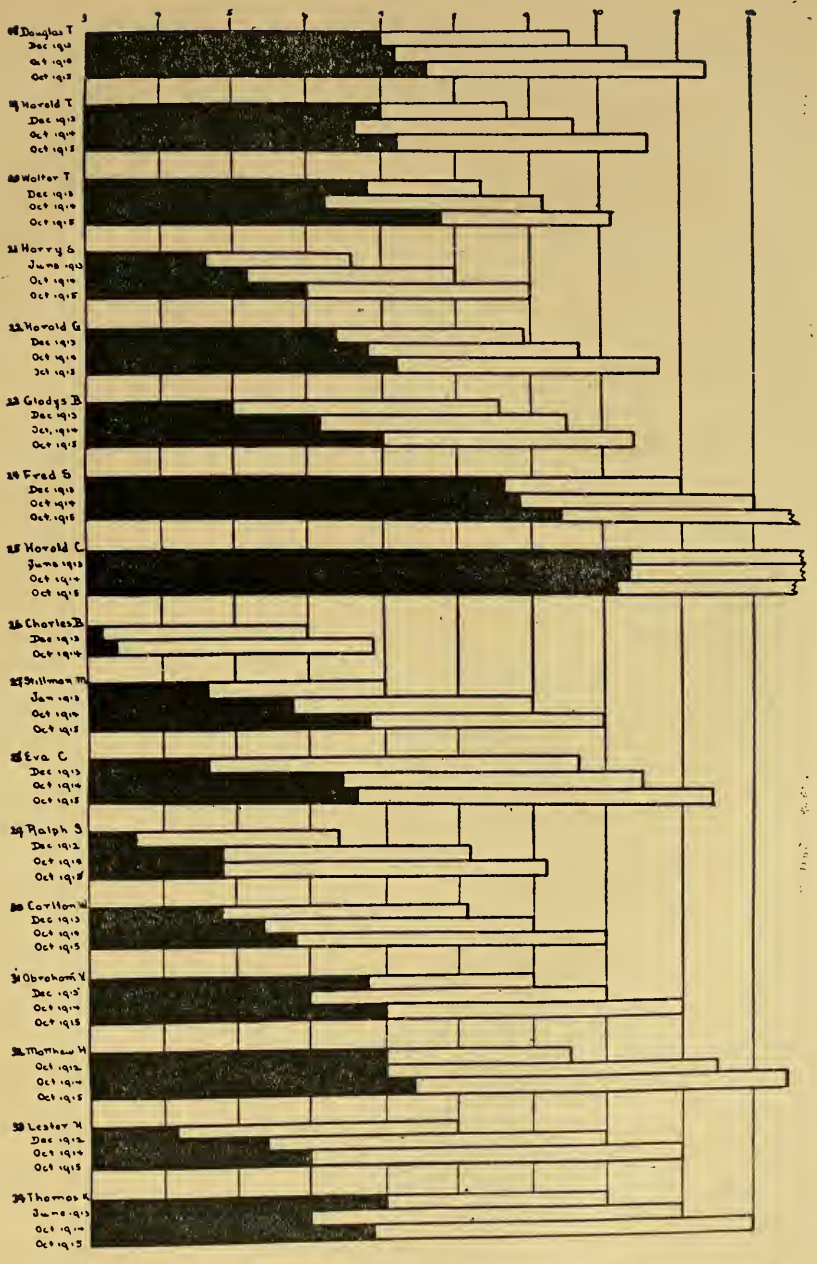


CHART SHOWING MENTAL AND PHYSICAL AGES OF 52 CHILDREN WITH DATES OF EXAMINATION. NOS. 18–34.

Mental age development in 'borderline' subjects showing arrested growth before 10 years of age with consequent decrease in I. Q.'s. Shaded areas show mental ages, unshaded areas life ages. (From ref. 26.)

FIG. 11—Section B

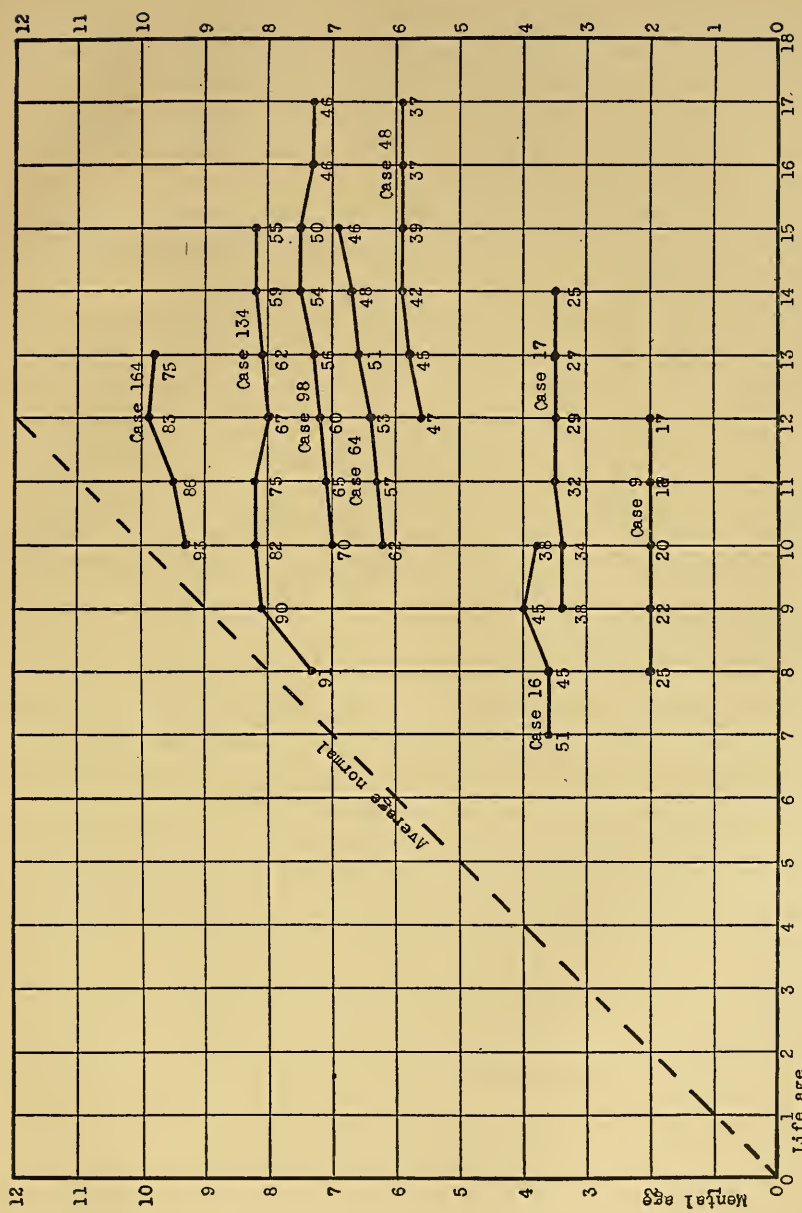
this material we have made calculations for the first 10 cases (excluding case 7 because of an error) which are presented in Table 14. This table shows the marked fluctuations which take place from year to year in annual rate of growth while the I. Q.'s remain approximately constant. The lack of agreement between I. Q. as a predicted rate and the actual rate for annual periods is obvious from this table.

Inspection of Fig. 11 shows very clearly complete arrest of development for two subjects under 10 years of age (mental ages 7 and 5). Complete arrest is also shown for four additional subjects whose ages are under 12 years (mental ages about 7). Since the subjects are all doubtfully feeble-minded at the first test these results are particularly striking. Our own results on potentially feeble-minded case shows similar effects with longer time periods (*cf.* Table 5).

Striking results for individual feeble-minded subjects were also presented by Mateer (25). Curves of mental age growth were plotted for 8 subjects whose I. Q.'s at the first examination ranged from 98 to 104. Four subjects whose initial life ages were 7 years made less than one year of mental age increase in four years. Another subject made no progress the first year and then made 100 per cent progress per year for 3 years. Another made no progress for 2 years and then 70 per cent progress for 2 years. Dr. Mateer concludes that an individual's I. Q. "may decrease steadily through even the earlier years, it may stand still, or it may even temporarily increase."

The writer has elsewhere (9) presented several case records of mental ages designed to show that for any grade of feeble-mindedness I. Q.'s may decrease steadily from I. Q. 100 or temporarily increase when markedly under 100. This paper also indicated marked fluctuations of I. Q. among normal subjects. In another paper (10) the writer has defined 'potential feeble-mindedness' as a type of feeble-mindedness where the I. Q. is close to 100 in early tests but drops rapidly in later tests (*cf.* successive I. Q.'s in Fig. 9).

Finally we offer from the experimental data of the present study graphic results of individual feeble-minded subjects.



Individual growth curves showing early arrest with consequent I. Q. decrease.
(Numbers below the curves denote I. Q. values.)
FIG. 12

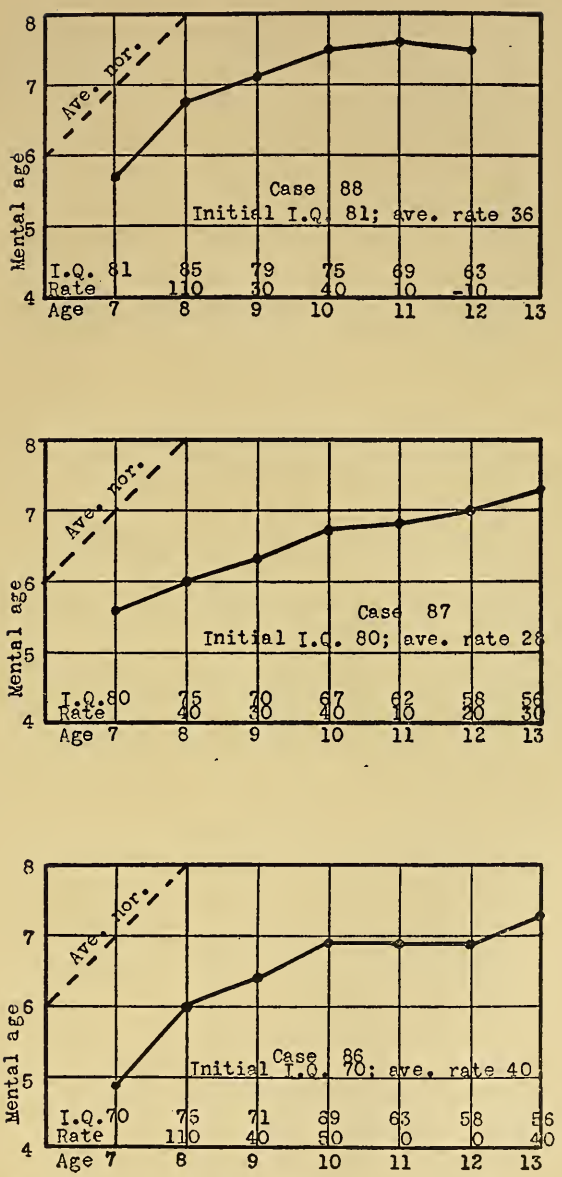
Growth curves of particular developmental types are presented in Figs. 12 to 15. These curves are 'smoothed' (as described on page 42) and are therefore more regular than they would be if we had used the original mental ages. This smoothing enables us to plot uniform age-periods which makes the calculations simpler and the comparisons easier.

Fig. 12 shows the curves of 8 subjects of all degrees of ultimate feeble-mindedness, who are arrested in mental age growth relatively early in life. The first I. Q.'s of two of these subjects are above 90.[13] Since we are dealing here with institutional subjects this is rather remarkable, though such types are undoubtedly not uncommon among ultimately feeble-minded children in the public schools. That they are not more frequently encountered is due to lack of early examining coupled with repeated tests. All these 8 subjects show continuously decreasing I. Q.'s. The theory of a constant I. Q. requires that these subjects develop at rates varying from 25 to 93 until they are 16 years old, but as a matter of fact their net average rates are practically zero at 10 years or earlier.

Fig. 13 shows a series of 21 curves of subjects whose initial I. Q.'s are above 70 but whose net average rates of growth are below 50. These subjects are all gaining in mental age, but their net average gains are for the most part 50 per cent *less* than the rate predicted by the theory of a constant I. Q. Their I. Q.'s are therefore steadily decreasing. Nearly all of these subjects entirely cease to develop several years before age 16, the theoretical limit to which they are expected to develop at a constant rate by the I. Q.

Fig. 14 shows 3 subjects who reach points of arrest at 12 or 13 years of age, but who prior to that point are developing at a net average rate which is 50 per cent *greater* than the rate expected from the initial I. Q. Their I. Q.'s are therefore steadily *increasing*. Finally, Fig. 15 shows three subjects whose net average rate of growth corresponds approximately to the initial I.

[13] An I. Q. of 90 is ordinarily considered indicative of 'normal' intelligence as well as average intelligence. These subjects were diagnosed as potentially feeble-minded on the basis of clinical evidence which outweighed the 'at-ageness' of the Binet mental age score (*cf.* 8, 10, and 25). Subjects No. 134 and 164 have been fully reported in (8) pp. 90 to 140.



Individual growth curves showing average rate of increase about half of initial I. Q. with consequent decrease in I. Q. values.

FIG. 13—SECTION A

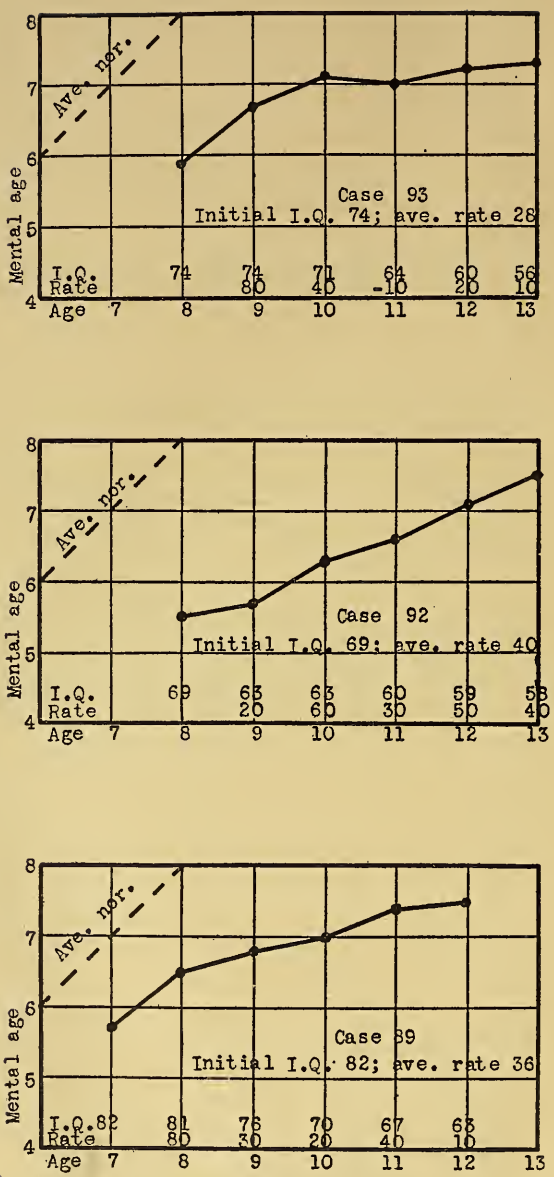


FIG. 13—SECTION B

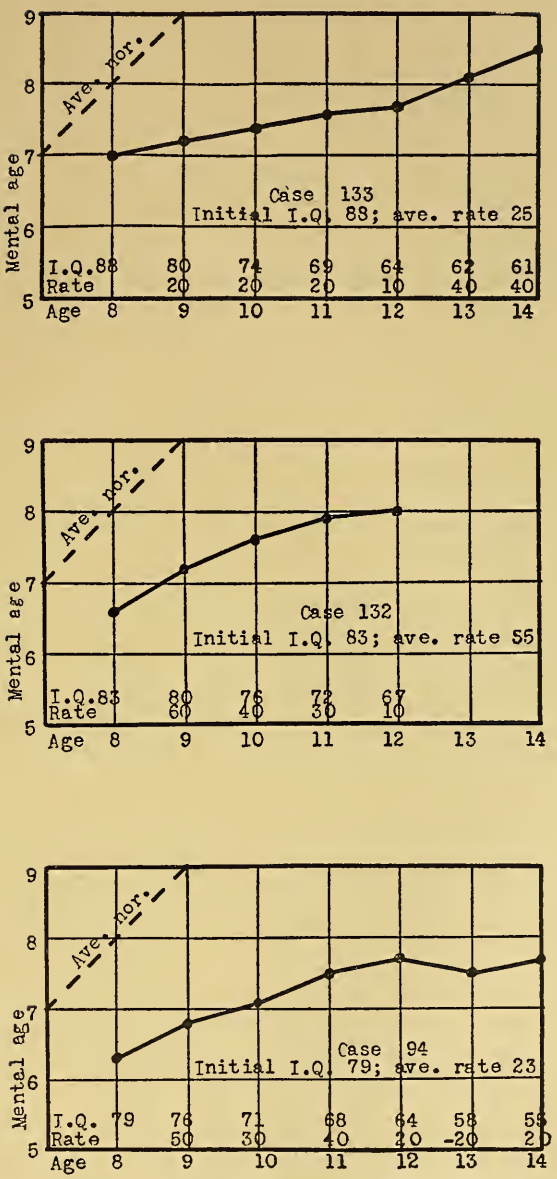
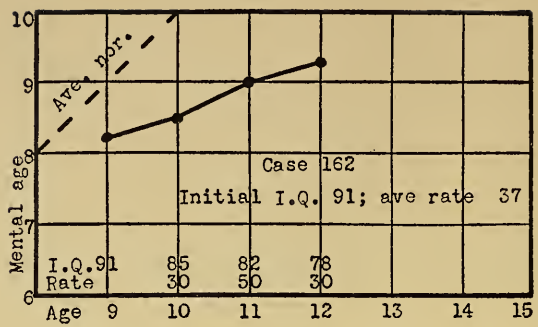
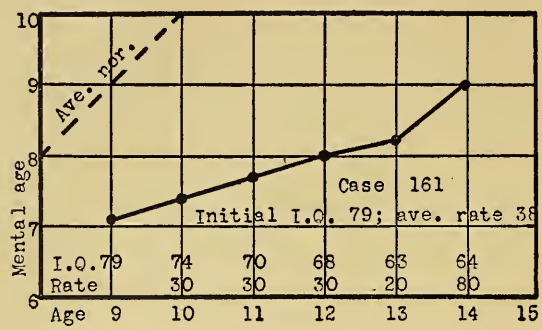


FIG. 13—SECTION C





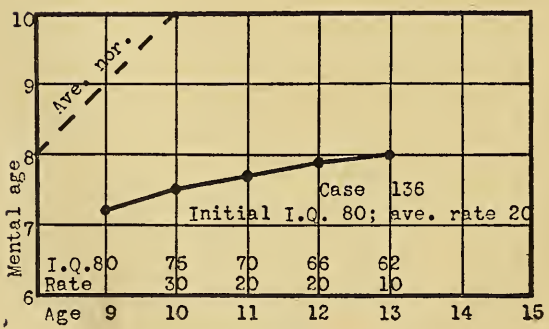


FIG. 13—SECTION D

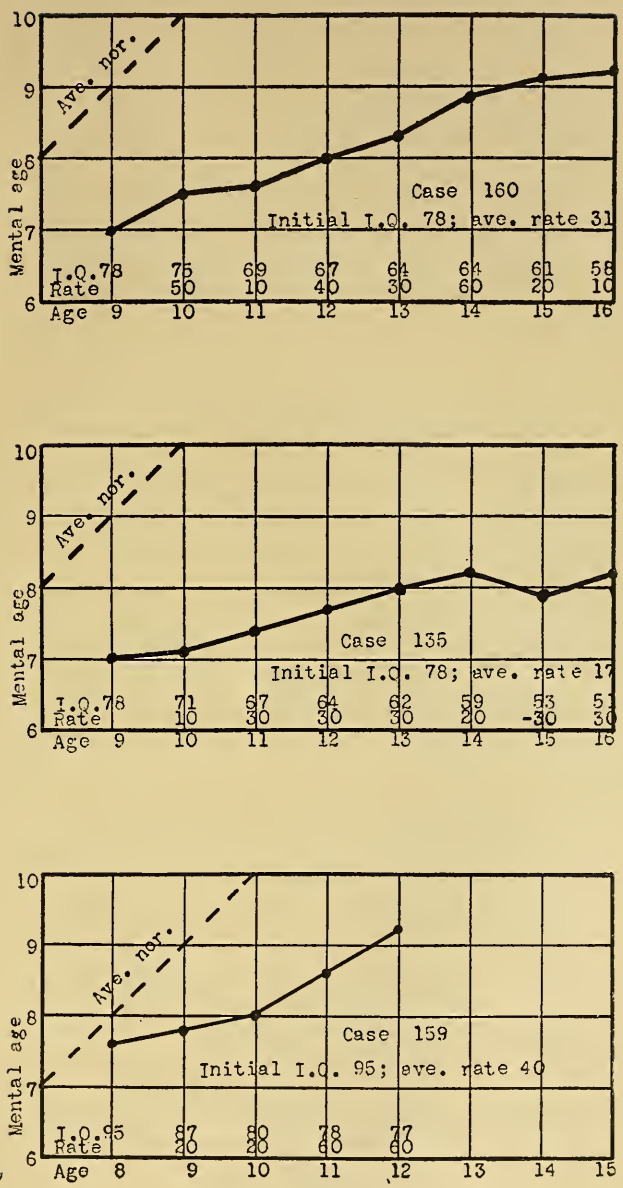


FIG. 13—SECTION E

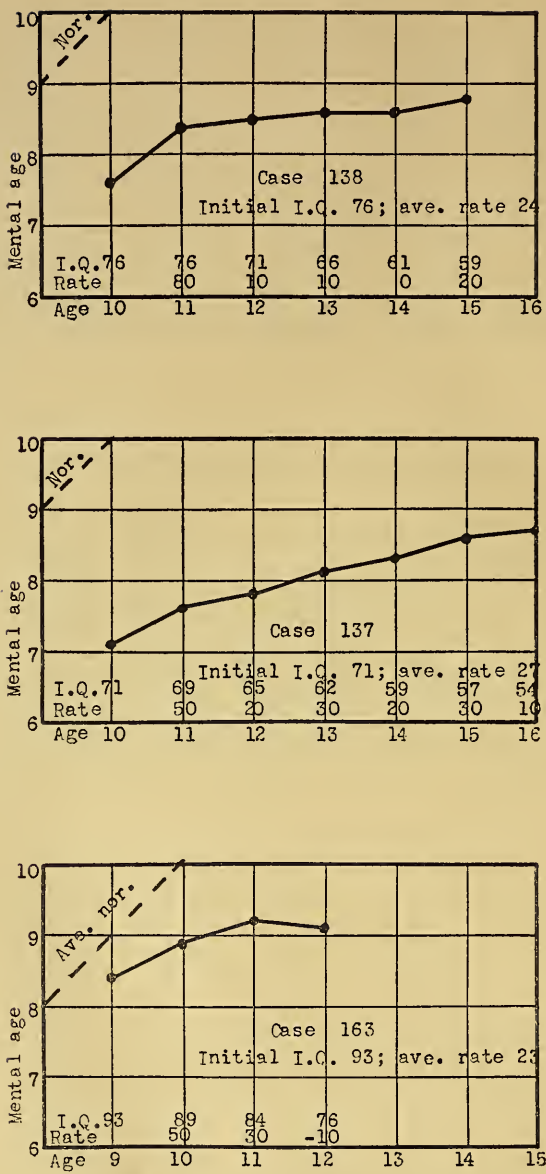
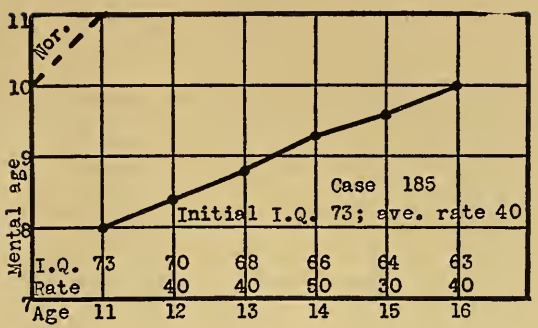
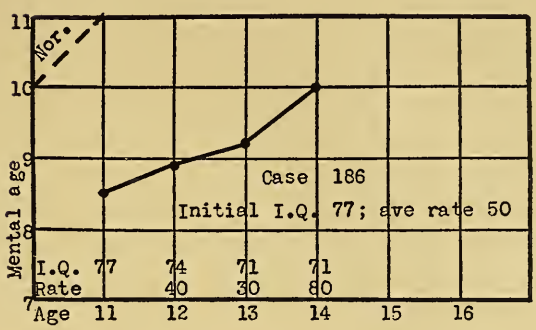


FIG. 13—SECTION F





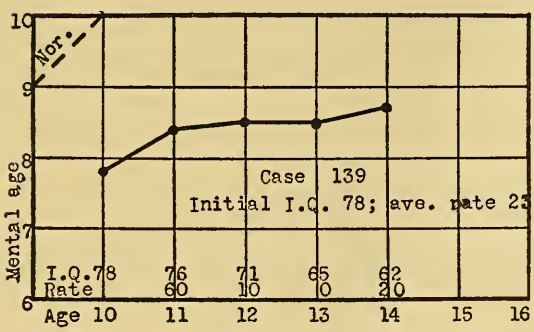
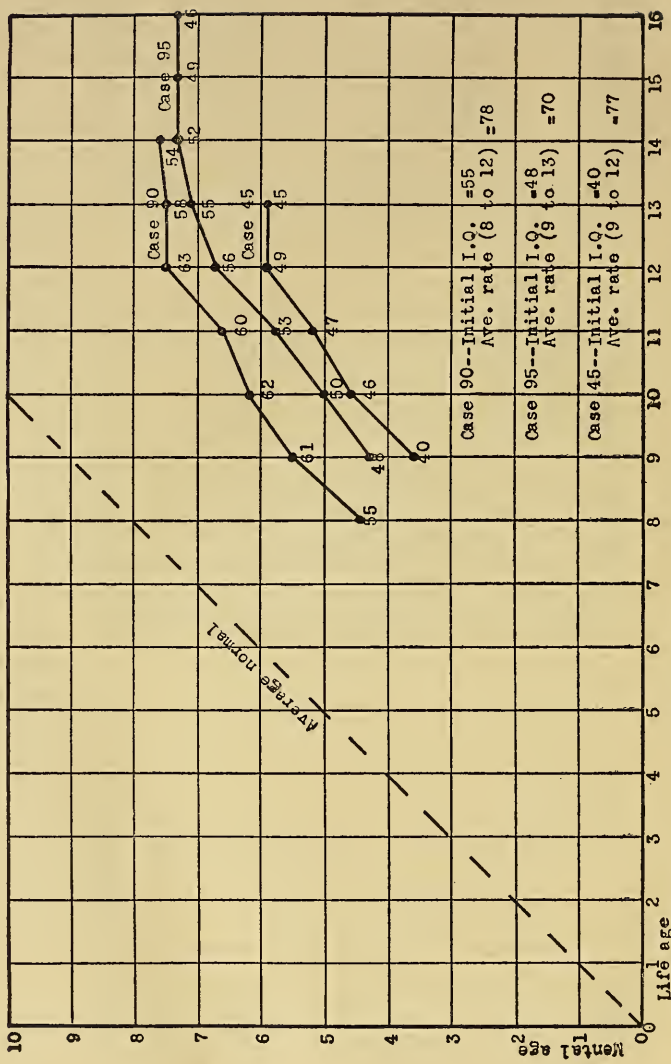
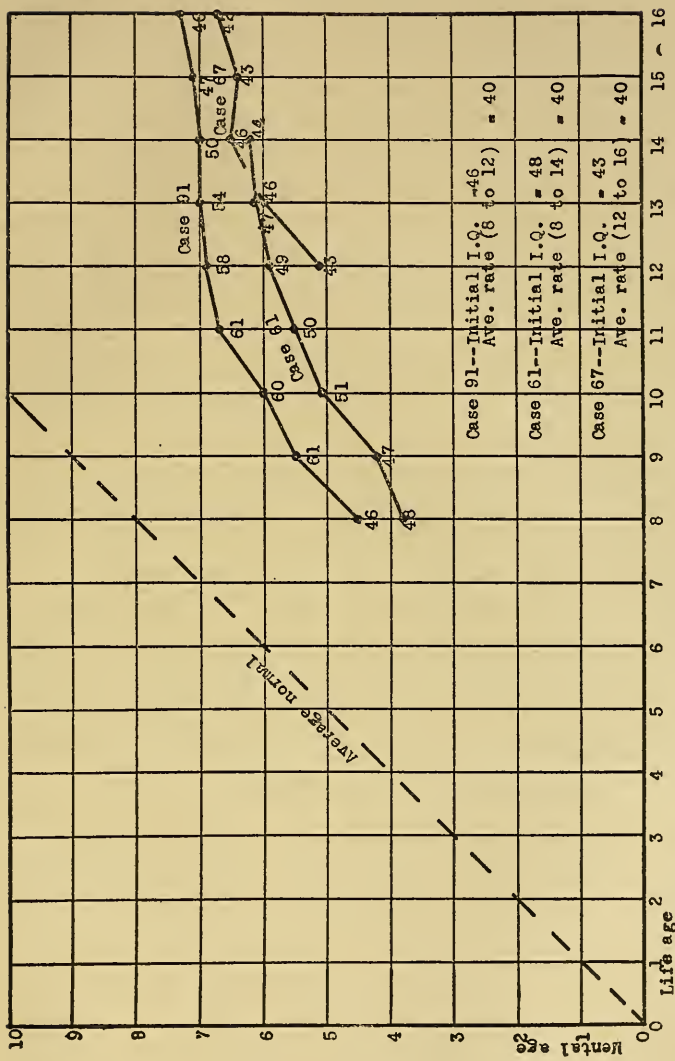


FIG. 13—SECTION G



Individual growth curves showing average annual rate of mental age increase greater than I. Q. prediction with consequent increase in I. Q. values.

FIG. 14



Individual growth curves showing approximate agreement between average annual rate of mental age increase and initial I. Q. with consequent constancy of I. Q. values for limited periods of time.

FIG. 15

Q.'s. But two of these three reach a level of arrest at about 12 years of age instead of 16.

We may therefore conclude that only 1 subject out of a total of 106 feeble-minded subjects who were below 16 years of age at the first examination maintains an I. Q. which is in accord with the theory that the I. Q. is constant. In opposition to this theory we are obliged to conclude for the feeble-minded at least that there are as yet no obvious laws of mental age growth which can be made practical use of in predicting development in the individual feeble-minded subject. We must for the present content ourselves with the general laws that, (1) there is an age of arrest for every feeble-minded subject which almost invariably is reached before 15 years of age, (2) that this age of arrest is a function of the final mental level, and (3) that the level is reached at a rate or growth which is a decreasing variable and is a function of life age.

We have plotted only the growth curves of certain conspicuous types. In so doing we have justified the theoretical argument advanced at the beginning of this report (*cf.* pp. 15 ff.). Other curves may be readily plotted from the data in Table 2.

That these developmental types exist even in small numbers is a fact which cannot be ignored by clinical psychology. We agree with Dr. Mateer that mere 'at-ageness' in intelligence is not necessarily diagnostic of normality and even a few curves prove the point. The issue is clearly and forcefully presented by Dr. Mateer in the following paragraph (25, p. 391):

> There is something more significant than mere mental age or years of retardation, a something we seem to have missed in our numerically finished clinical studies. At two an idiot, an imbecile, a moron and a normal may all seem practically the same. Then the idiot drops out of the race, stays at that level. Somewhere, in the next four or five years the imbecile falls behind, but the moron may be even ten or eleven before he evidences any real deficiency on our present system of tests. Yet the difference has been there all along. The moron was as feeble-minded, potentially, at the age of two, as at twelve. The normal child was as surely normal. There is an innate difference hard to describe, but all who know defective and normal children often recognize this qualitative difference before any quantitative test has demonstrated its presence. It seems as though with some the evolutionary nisus has spent itself with the effort necessary to bring into being, with

others there is no energy there to meet the demand for speech, with others concrete stimuli can evoke satisfactory responses but there is not enough motive power to meet the demand for response to the faint stimulations made by abstract ideas, theories, principles, etc. But the normal child is entirely different. He lives only as an incarnation of activity, he is activity, innate, flooding, spilling with every new stimulus, responding with growth to every new demand made upon him.

With respect to irregularities in the mental growth of individual superior children we may cite 5 cases from Terman (29, pp. 194 ff.), and 4 from the data supplied us by Miss Gillingham. The latter data are for subjects who have been examined three times at intervals of from 1 to 2 years. We present the results in Table 15, showing the successive ages and mental ages for each subject, the increases in ages and mental ages, the I. Q.'s, the corresponding annual rates of growth, and the I. Q. changes.

The column headed 'Annual rate' shows marked irregularities in the same subject from year to year, varying in one subject from 370 per cent of the normal rate to 10 per cent. There are also marked differences between the I. Q.'s as predicted rates and the actual rates. The I. Q. changes are comparatively slight, even when the differences between actual rates and predicted rates are very marked. As has already been pointed out, this is because the variation in rate is 'taken up' in the I. Q. change by being distributed over a period of years equal to the age of the subject.

From all this evidence we may conclude that marked irregularities in the course of mental growth of subjects from year to year are actually present and easily observed. But these irregularities are obscured by the I. Q. mode of expressing mental growth, since the irregularities are smoothed in the I. Q. by being distributed over a period of years. We may also note that these irregularities are not always in the same direction and therefore tend to compensate each other over periods of time which are longer than one or two years. But the irregularities are too large in amount to be traced to experimental variations in the conditions of obtaining mental age. In other words, the observed tendency of superior children to become still more su-

TABLE 15

Irregular rates of mental age growth of superior children.

Subject No.	Life ages	Mental ages	I. Q.'s	Life age increases	Mental age increases	Annual rate of increase	I. Q. changes
			Terman's cases				
1	6.9	10.0	145				
	7.9	13.2	167	1.0	3.2	320	+22
	10.0	16.6	166	2.1	3.4	162	— 1
4	4.6	6.7	145				
	5.8	8.8	152	.8	2.1	262	+ 7
	7.0	10.7	153	1.2	1.9	158	+ 1
6	8.2	11.3	138				
	11.0	15.2	138	2.8	3.9	139	0
	12.3	17.6	143	1.3	2.4	185	+ 5
17	3.2	4.7	147				
	5.2	7.3	140	2.0	2.6	130	+ 7
	6.3	8.8	140	1.1	1.5	136	0
28	8.1	10.8	133				
	9.2	13.0	141	1.1	2.2	200	+ 8
	11.3	15.5	137	2.1	2.5	119	— 4
			Gillingham's Cases				
	10.7	13.8	130				
	11.7	17.5	150	1.0	3.7	370	+20
	12.7	17.6	139	1.0	.1	10	—11
	11.1	15.1	136				
	12.2	16.0	131	1.1	.9	82	— 5
	13.0	17.0	131	.8	1.0	125	0
	11.2	12.9	115				
	12.1	13.1	108	.9	.2	22	— 7
	13.2	15.8	120	1.1	2.7	246	+12
	11.4	12.8	112				
	12.8	14.7	115	1.4	1.9	136	+ 3
	13.8	16.3	118	1.0	1.6	160	+ 3

perior is not regularly maintained from year to year for individual subjects although it has seemed to be a significant tendency from superior children on the average.

The I. Q. and the scale of measurement.—Of course the constancy of the I. Q. will depend upon the accuracy of the mental age measuring scale. It will also be influenced by the care with which the exact life age is calculated and it will vary with such experimental conditions as Brigham (5) has so carefully investigated. The 'completeness' or 'range' of examining in par-

ticular will influence the I. Q., for if the first examination is not carried far enough into the upper ranges of the measuring scale this will exert a spurious influence. But in the long run the determination of the total mental age is fairly independent of these experimental variations, owing to compensating errors.

It is possible, however, that the mental ages obtained by different measuring scales might yield different arguments concerning the I. Q. Terman has said (30, p. 104): "It should be emphasized, however, that what we have said about the significance of various I. Q.'s holds only for I. Q.'s secured by the use of the Stanford revision. As we have shown elsewhere (p. 62 ff.) the I. Q. yielded by other versions of the Binet tests are often so inaccurate as to be misleading."

Our principal experimental evidence concerning the intelligence growth of feeble-minded subjects is based on the Goddard version of the Binet tests. Most of our references to the literature are also based on authors who for the most part used the Goddard scale. Does this fact invalidate our argument? We think not and for the following reasons.

We readily acknowledge that the Stanford revision is a much superior instrument to the Goddard scale. This is not, we believe, due to the increased number of tests, selection of tests or to any fundamental difference in principles of standardization. It is due to greater care in the selection and examining of subjects on whom the Stanford Scale was standardized, and to greater care in the statistical treatment of standardization data. Another principal advantage, and one which is much more important than the improved accuracy of standardizations is the *extension* of the Stanford Scale for the measurement of the higher mental ages.

We have shown (*cf.* Fig. 4) that the Goddard Scale gives a close approximation of median mental age to median life age up to age 10, with minor inaccuracies not very much greater than those of the Stanford Revision (*cf.* Fig. 5). But a better demonstration of the superiority of the Stanford Scale is found in the *calibration* of the two scales. If we apply the method of Otis (27) to the two Scales, we find that whereas the Goddard

Scale is inaccurately calibrated with respect to the succession of tests, the Stanford Scale shows only minor inaccuracies of calibration. The principal inaccuracy of the Goddard Scale is between 7 and 8 years. At other ages the standardization is fairly accurate. The writer has elsewhere shown (7) that this calibration is slightly different for feeble-minded subjects. It has also been pointed out that the Goddard Scale does not accurately measure mental ages higher than 10 years. With superior subjects its limit of efficiency is probably only 9 years.

But none of these arguments seriously affects our results for the feeble-minded. The Scale is sufficiently extended for all but possibly the highest group of subjects, those whose final mental ages are 10 years. If we left out this group of subjects our conclusions would not be materially affected.

For the total range of the Goddard Scale we should have matters somewhat as follows (*cf.* Fig. 4): between 5 and 6 years a year's improvement in true mental age would register (on the average) as 1.6 years, between 6 and 7 as 1.1 years, between 7 and 8 as .6 years, between 8 and 9 years as .5 years, between 9 and 10 years as 1.2 years, and between 10 and 11 as 1.1 years. Therefore, when converting mental age increase to rates of development we ought not to have divided the actual gains by 1.0 as the average annual rate of growth, but should have divided by 1.6 at mental age 5, 1.1 at mental age 6, .6 at mental age 7, and so on. The serious changes would be at mental ages 5, 7 and 8. In other words, the 5-year-old, who is expected to gain only half a year from the tests beyond year V, actually gains a year, and so does the 6-year-old. This is because the VI-year and VII-year tests are too easy. The 7-year-old finds the tests properly adjusted and 'tests' as he should, but the increase from age 6 to 7 is only a half year because at age 6 the subject 'tested' too high. The 8-year-old, however, tests a half-year too low because the VIII-year and IX-year tests are too hard for him, although a year later he finds them easy enough. In other words, as our calibration of the Goddard Scale shows, there will be irregularities in the mental growth rates at ages 5 to 6, 7 to 8, and 8 to 9.

But if this is true for the Goddard Scale it is also true for the Stanford Scale, though at different points (*cf.* Fig. 5). On the Stanford Scale the average child will gain 1.4 years between the ages of 4.5 and 5.5 and only .7 years between the ages of 5.5 and 6.5.

It appears, however, that the younger subjects of both Goddard and Terman were selected in favor of brightness. Hence the discrepancy at 5 and 6 years may be overlooked. The Stanford Scale then becomes a regular measure at all ages while the Goddard Scale is inaccurate only between 7 and 8 years. This is just what the Otis calibration of the Goddard Scale shows.

The effect of this attenuation of the Goddard Scale is to cause an irregularity in rate of mental growth at about the age of 8 years. The average normal rate of growth between 7.5 and 8.5 years is only half of the theoretical standard rate of 100 per cent.

The conclusion of this argument is, then, that when the Goddard Scale is applied to unselected average normal subjects whose mental ages are below 10 years, the rate of growth of unselected subjects will be approximately 100 for all ages except mental age 7.5 to 8.5 years. Variations from the approximate standard of 100 will be equally marked in the Stanford Scale except for this one year.

This fact might be expected to influence our mental age curves (Fig. 10) at final mental ages 7 years, 8 years, or 9 years. In fact the growth curve for final mental age 9 is affected while passing from 8 to 9 years. We cannot be sure that this is more than a coincidence, however, for the irregularity comes nearly a year later than one would expect from the theoretical considerations advanced above, which have indicated that these subjects should have met with difficulty in crossing the 8-year boundary rather than the 9-year boundary.

Another course of argument might be carried out somewhat as follows. We may assume that the Stanford Scale is acceptably accurate for measuring mental age. The relative accuracy of the Goddard Scale may then be determined in terms of the Stanford as a standard of comparison. Unfortunately we are

unable to refer to any study of a large number of subjects examined by both Scales. But in 1916 Miss Eleanor E. Gray, then a research assistant at the Training School, examined 82 institutional feeble-minded subjects in this way. Both scales were employed at the same sitting for each subject, identical tests being given only once and scored on both scales. Statistical treatment of these results gave a correlation of $r = .98$ for the exact comparative mental ages of the 74 subjects whose mental ages were below 11.0 by the Goddard Scale. The I. Q. correlation would be exactly the same, since for each subject the life age was the same for both mental ages. But this high correlation for the entire range of mental ages is somewhat misleading. The average results by separate mental ages are more striking. They are presented in Table 16. This table shows that the God-

TABLE 16

Comparison of mental ages obtained by examining the same feeble-minded subjects with the Goddard Binet and Stanford Binet Scales.

Mental age group	No. cases	Ave. M.A. Stanford	Ave. M.A. Goddard	Average difference	Annual increase Stanford	Annual increase Goddard
2	5	2.72	3.08	.36		
3	5	3.50	4.04	.54	.78	.96
4	7	4.44	5.12	.68	.94	1.08
5	6	5.52	6.37	.85	1.08	1.25
6	8	6.50	7.40	.90	1.02	1.03
7	7	7.30	7.83	.53	.80	.63
8	8	8.38	8.75	.37	1.08	.92
9	15	9.60	9.73	.13	1.22	.98
10	10	10.44	10.36	—.08	.84	.63
11	4	11.45	11.05	—.40	1.01	.69
12	5	12.44	10.92	—1.48	.99	—.07
13	2	13.40	11.20	—2.20	.96	.32

dard Scale yields higher mental ages at all stages up to mental age 10 years. This is another way of showing what we have already shown in the comparative calibrations of the scale, namely, that the Goddard Scale is comparatively easier than the Stanford Scale in the early mental ages, and is not an efficient measure of mental age after 10 years. Up to mental age 8 years all but two subjects have higher mental ages by the Goddard Scale. ranging from a minimum of .1 years to a maximum of 1.3 years for individual subjects. At Stanford mental age 8 years, 60 per cent of individual mental ages are higher by the Goddard Scale, at 9 years 60 per cent, and at 10 years 30 per cent.

The principal feature of comparison, however, is that the *average annual increases* in mental age are much the same by both scales. While the comparative mental ages are different from year to year the comparative mental age *increments* are never greater than .2 years, that is are approximately the same for both scales from year to year. Since in this study we are concerned primarily with mental age *increases* rather than with true mental ages, we may say that *the measurement of mental growth for feeble-minded subjects under mental age 11 years is about as accurate by the Goddard Scale as by the Stanford Scale.* The Stanford Scale is undoubtedly the more accurate scale for measuring actual mental age and should in future be used in preference to the Goddard Scale. Nevertheless the Goddard Scale at its most inaccurate segments gives mental ages which do not differ as much as a year from those obtained by the Stanford Scale. It is almost exactly as accurate as the Stanford for measuring mental age increases. The comparative inaccuracy of the Goddard Scale is certainly not so great as to discredit our results for feeble-minded subjects on that basis.

Still another argument to substantiate our use of the Goddard Scale is that although this scale may be irregular at certain points (which is true only in lesser degree of the Stanford Scale) it is not so irregular as to prevent the measurement of actual *growth* if the period of time is sufficiently extended or if the tendency to grow is sufficiently pronounced. We have shown that the greatest inhibition of mental age increase (by the Goddard Scale) among average normal subjects occurs at 8 years and that this temporary inhibition is later overcome by the 'facilitated' or too easy mental age increase at other years. Hence the worst we could expect from an admittedly imperfect scale would be to find *irregularities* in our average growth curves (Fig. 10). This influence might also bring about a piling up of subjects at certain mental ages, such as mental age 5, which piling up ought to include some subjects whose 'true' final mental ages are only 4 years. We ought also to find that those subjects whose initial mental ages are about 4 years should make spurious gains, while those whose initial mental ages are about 7 years should

be spuriously arrested. These effects would only in part be obscured by our method of grouping according to final mental age.

As a matter of fact we do find a slightly increased rate of growth between mental ages 4 and 5 years for those subjects whose final mental age is 6 years. And we do find a slight piling up of subjects at mental age 7 years. And it may be that the slope of our curve, for final mental age 8 years is unwarrantedly flat. But these effects may just as well be the results of causes other than the irregularities of the scale, being caused possibly by the small numbers of subjects, the marked variations in the growth of individual subjects (which would be reflected in the small number of subjects), the accidental age-factor in the selection of subjects, and so on. Moreover, the effects noted in the curves are not exactly as predicted. The piling up of subjects should be in the 8-year group instead of the 7-year group, and the rapid rate of growth should be in the 5-year group instead of the 6-year group. And some subjects in each group are arrested while others advance in mental age.

A large number of the subjects of our experimental study were examined by the Stanford Scale as well as by the Goddard Scale. Some were examined for several years by both scales. We have not been in a position to work up these results, but inspection of the data indicates that they would substantiate the above conclusions. The Stanford mental age scores are usually a half year lower than the Goddard mental age scores, but the rates of increase by both scales are closely similar. In particular it cannot be said that the condition of potential feeble-mindedness is a reflection of an inadequate scale. The results of Dr. Mateer support our own evidence that sudden arrest in mental development is equally obvious by either scale.

From all these considerations we may conclude that the Goddard Scale is a valid scale for our purposes no matter from what angle it is viewed. The argument is of course crucial to the validity of our conclusions with respect to the feeble-minded. Our other results are above reproach in these respects, being based on the Stanford Scale.

IV. SUMMARY AND CONCLUSIONS

1. Intelligence is defined in this study in terms of its essential activities: judgment, comprehension and reasoning. The growth of intelligence is here measured by comparing successive Binet mental ages of the same individuals obtained by repeated examinations over long periods of time.

2. The accepted theoretical curve of average normal growth of intelligence misrepresents the probable facts. Logical considerations and the facts of child study suggest significant modifications of the theoretical curve of growth which is commonly accepted in the psychology of intellectual development. For practical purposes an empirical straight-line curve of average normal growth in terms of relative units of mental age may be employed as a standard of comparison.

3. The experimental proof is inadequate regarding the mental age which shall be accepted as representing average normal adult intelligence. The most recent and extensive evidence suggests that the average adult level of intelligence is between 13 and 14 years instead of being 16 years as has been recently accepted in the field of clinical psychology. The final disposition of this question is complicated by the difficulty of obtaining representative unselected subjects in the higher life ages.

4. Repeated Binet tests almost inevitably show an error of incomplete examining. To correct this error a set of objective rules are developed to supply scores for single test-scores which may have been omitted from an examination.

5. When the growth of intelligence of feeble-minded subjects is experimentally investigated by comparing successive mental age increases as a result of repeated examinations of the same subjects, the following 'laws' of growth are established:

a. Significant mental age increases are limited to subjects under 15 years of life age.

b. The age of final mental arrest is determined in largest measure by the final mental age level (hereditarily predetermined?) and cannot be predicted from a given mental age or a given degree of mental retardation such as may be evident from

one or several examinations early in life by any present device for expressing intellectual development.

c. The rate of intellectual development is a function of the life age of the individual subject. It is relatively independent of the final mental level or an initial degree of retardation.

d. The average annual rate of growth is relatively independent of the contemporary mental age level. It decreases by increasing amounts as life age increases. It reaches a minimum at about 13 years of life age.

6. The rate of growth of superior children between the ages of 9 and 13 years life age is negatively correlated with mental age and degree of brightness. Individual variability in the rates of intellectual growth of superior children is very marked.

7. No conclusion is established regarding the age of arrest of intellectual growth among superior children.

8. The conclusions established by this experimental investigation are in harmony with theoretical expectation founded on observation and the known facts of intellectual growth.

9. The contention of several authorities that the intelligence quotient is approximately constant between the ages of 4 and 16 years of life age for all degrees of brightness is not justified either by theoretical considerations or by the experimental evidence now available in the literature of the subject.

10. 'Approximateness' of I. Q.'s may be expressed numerically. When this is done it is evident that equal rates of annual growth yield markedly different degrees of approximateness at different ages.

11. The I. Q. instead of being approximately constant is markedly variable in individual cases. The likelihood of an I. Q. remaining approximately constant can be expressed in terms of probability with a fair degree of accuracy. Except in this way no single I. Q. can safely be used as a means of predicting individual mental age growth with certainty or accuracy.

12. Marked irregularities in the rates of growth of intelligence among individual children of feeble-minded, borderline, and superior children are demonstrated by growth curves covering long periods of time. The data are insufficient to indicate the periods at which intellectual growth is retarded or accelerated.

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